...Lace	The late W. FELKIN (Nottingham).
...ets	CHRISTOPHER DRESSER, Ph.D.
...g and Bleaching ..	T. SIMS (Mayfield Print Works).
...ry	L. ARNOUX (Art Director of Minton's Manufactory).
...s and Silicates	PROF. BARFF, M.A., F.C.S. (Kensington Catholic University).
...iture and Woodwork ..	J. H. POLLEN, M.A. (S. Kensington Museum).
...r	PROF. ARCHER, F.R.S.E. (Director of Edinburgh Museum of Science and Art).
...ting and Bookbinding ..	JOSEPH HATTON.
...raving	SAMUEL DAVENPORT (Society of Arts).
...ography	P. LE NEVE FOSTER (Society of Arts).
...ys	G. C. BARTLEY (South Kensington Museum).
...acco	JOHN DUNNING.
...es and Leather, Gutta-rcha and Indiarubber ..	J. COLLINS, F.B.S. (Edinburgh).
...es and Cordage	P. L. SIMMONDS, F.R.C.I.
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...tches and Clocks	F. J. BRITTEN (British Horological Institute).
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Sugar Refining	C. HAUGHTON GILL (late Assist. Exam. Univ. of London).
...tter and Cheese	MORGAN EVANS (late Editor of 'Milk Journal').
...ewing and Distilling ..	T. POOLEY, B.Sc., F.C.S.
...dustrial Statistics	G. PHILLIPS BEVAN, F.G.S.

London: Edward Stanford, 55, Charing Cross.

BRITISH

MANUFACTURING INDUSTRIES.

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EDITED BY

G. PHILLIPS BEVAN, F.G.S.

POTTERY,
BY L. ARNOUX, Art Director and Superintendent of Minton's Factory.

GLASS AND SILICATES,
BY PROFESSOR BARFF, M.A.

FURNITURE AND WOODWORK,
BY J. H. POLLEN, M.A., South Kensington Museum.

LONDON:
EDWARD STANFORD, 55, CHARING CROSS.

1876.

PREFACE.

THE object of this series is to bring into one focus the leading features and present position of the most important industries of the kingdom, so as to enable the general reader to comprehend the enormous development that has taken place within the last twenty or thirty years. It is evident that the great increase in education throughout the country has tended largely to foster a simultaneous interest in technical knowledge, as evinced by the spread of Art and Science, Schools, Trade Museums, International Exhibitions, &c.; and this fact is borne out by a perusal of the daily papers, in which the prominence given to every improvement in trade or machinery attests the desire of the reading public to know more about these matters. Here, however, the difficulty commences, for the only means of acquiring this information are from handbooks to the various manufactures (which are usually too minute in detail for general instruction), from trade journals and the reports of scientific societies; and to obtain and systematize these scattered details is a labour and a tax upon time and patience

which comparatively few persons care to surmount. In these volumes all these facts are gathered together and presented in as readable a form as is compatible with accuracy and a freedom from superficiality; and though they do not lay claim to being a technical guide to each industry, the names of the contributors are a sufficient guarantee that they are a reliable and standard work of reference. Great stress is laid on the progressive developments of the manufactures, and the various applications to them of the collateral arts and sciences; the history of each is truly given, while present processes and recent inventions are succinctly described.

BRITISH MANUFACTURING INDUSTRIES.

POTTERY.

BY L. ARNOUX, Art Director and Superintendent of Minton's Factory.

WITHOUT entering into an elaborate dissertation on the antiquity of the Art of Pottery, which would be out of place in so short an article as this, I will briefly state that the practice of making vessels from plastic clays, for holding liquids and provisions, first resulted from the exertions made by man to emerge from his primary condition. It is a well-known fact that vessels of clay, only partially baked, have been found, together with stone implements belonging to prehistoric times, and that those vessels, unfinished as they were, had peculiar characteristics. But supposing that this was not so, it must strike everybody, that after providing himself with those rude instruments wherewith to obtain his food and protect his life, man must have taken advantage of his power of observation to notice the property of plastic clay to retain water, and to find out to what useful purpose it might be brought for making vessels better suited to his wants, than the skins of animals or pieces of wood roughly hollowed out. If not probable,

it is however not impossible, that the first man, taking in his hand a lump of soft clay, should have tried to give it a defined shape, in which case the art of pottery would be as ancient as the human race. It may have been anterior to the use of fire, for a sound and useful pottery may be made with clay hardened in the sun, as still practised in Egypt and India. At all events, it existed previous to the working of the first metal, as one can hardly understand how bronze could have been melted without the assistance of vessels made of fired clay carefully selected. Consequently it is admitted by everybody, that this is one of the earliest of human inventions, and that the material has proved most durable. This durability, secured by the application of heat, is a very remarkable phenomenon; for while many other materials, apparently very hard, have been found unable to stand the atmospheric changes or the continuous contact with a damp soil, it was sufficient to submit this one to a very moderate heat, to be enabled to resist these various agencies for several thousands of years. This is particularly noticeable in the black Greek pottery, which, while possessing all its former appearance, can, however, be scratched by the nail or broken by a gentle pressure between the fingers. It is thus that we are indebted to the art of pottery for innumerable works of art, many of which have proved most useful in elucidating historical facts, and making us acquainted with the habits, dresses, and ceremonies of ancient peoples.

One can understand how difficult it is to decide who were the earliest potters. It is a question that

archæologists have often tried to answer, but which is not likely to be ever solved. Pottery was created to meet a special want of the human race, and we find early pottery existing in almost every part of the world, in unknown America, as well as in Europe or Asia. It is, however, easier to decide which people first excelled in it, and in this respect we must give equal credit to the Egyptians and the Chinese. It is mentioned in sacred history that more than 2000 years B.C. the Egyptian potters were celebrated for their skill, and if we can believe Chinese tradition, the manufacturers in China were at this same time under the control of a superintendent appointed by the government. Unfortunately, we have very little information respecting the history of the art in China previous to the sixteenth century; and although we have a notion of what they did and how they did it, it is wiser, with our imperfect knowledge, to abstain from speculating as to when the different sorts of Chinese ware were produced. But as regards the Egyptians there is no uncertainty; some of their ceramic relics bear their own inscriptions, and others have been found associated with objects or monuments whose dates have been carefully ascertained. We may well believe in their skill when we know that they were acquainted with the most difficult processes for making the bodies and glazes, and that they used the same metallic oxides for colouring their ornaments that we are now using, though often, let us acknowledge, with less success. During a period of at least eleven hundred years, from the eighteenth to the twenty-fourth dynasty, they dis-

played considerable ingenuity in the production of small figures, jewellery, ornaments, and hieroglyphic tablets, in which several sorts of pottery mixtures and differently coloured glazes were most cleverly associated. It is from Egypt that sound principles of pottery making seem to have spread to the different nations; first to the Phœnicians, who in their turn became famous for their knowledge in the art of vitrifying mineral substances; and then to the Assyrians, who seem to have applied pottery more specially to the ornamentation of their buildings.

Greece, who shortly after received her first notions of art from the two former nations, did not devote her energies so much to improvement of material and richness of colour, as to the refined beauty of the shape and the excellence of the painting.

In pottery, the material is of little value, and it is only by the art displayed in shaping and decorating it that its price can be increased. In this respect the Greeks proved to what enormous value it could be raised, by making it the groundwork of their art, since sums equivalent to several thousand pounds of our money were readily paid by Roman patricians for a single Corinthian vase. In this, as in the other branches of art, the recognized taste of the Greeks will never be surpassed; and if at the present time little attention is paid by collectors to their ceramic productions, it is probably owing as much to the versatility of our tastes and fancies, as to our inability of showing the articles to their advantage.

The Greeks seem to have monopolized the ceramic

production of these fine works for seven or eight centuries at the least; for although vessels of the same description were largely produced in Italy, it was invariably by the Greeks, following closely the traditions and mode of decorations of their own country. It was only about a century B.C. that the Romans began to create a pottery on which they impressed their stamp, a pottery really their own; I mean that which is so improperly called Samïan and so easily known by its reddish colour and the embossed ornaments with which it is profusely covered. It is, however, genuine and characteristic, neatly executed, and possessing some standing qualities which did not belong to the Greek. On the other hand, the refinement is deficient; the forms are derived from the circle instead of the ellipse; the plain surfaces are replaced by embossments, and the painting is absent. For four centuries the Romans seem to have made this class of pottery in several of their European settlements, chiefly in Italy and in the provinces adjoining the Rhine. In the operation they seem to have required some special material unknown to us, which imparted to its bright red surface a semi-shining lustre or glaze, and which has proved remarkably durable. After this, the art of pottery experienced a time of darkness, when all the refined processes seem to have been neglected, and primitive vessels, like those produced by the Saxons, Gauls, and Celts, ranked amongst the best examples. The decorations, if any, are rudimentary; not only is the painting reduced in a few instances to some lines *or spots* made of a different clay, but even

the embossed ornaments are replaced by lumps of clay or impressed lines in a kind of geometrical disposition. Art was not quite dead, but it scarcely breathed. However, these specimens are not altogether uninteresting, for they were the first efforts of our forefathers, and there is always a certain pleasure in witnessing the feeblest attempts made in the research of art.

But the time came when pottery was to accomplish another revolution, no less remarkable than the first. Strangely enough, it was again from the East, in nearly the same province in which it originally took its rise, that it was revived, and it is not unlikely that some faint tradition of the old processes was the source whence sprung the new ceramic era, which was to extend to our own time.

The precise date of this revival is not positively ascertained; but it was probably contemporary with the establishment of Islamism amongst the Arabs. The energy displayed by this people in improving and adapting the different fabrics to the requirements of their new religion, was no doubt beneficial to the art of pottery, and with their fanaticism and spirit of proselytism, they carried their new ideas to every country which they conquered. Syria became a great industrial centre, and some of its towns, such as Damascus, were soon famous for the perfection of their wares. To reach Europe, however, this new movement did not take its course through Greece and Italy, as in the first instance; it was through Egypt and the North of Africa that, at the beginning of the eighth century, it made its way to Spain, where it became firmly established.

As regards pottery, nowhere were better specimens produced than in the towns of Malaga, Grenada, Cordova, and others, going northwards as far as Valencia and Toledo. The newest feature of the Arabian or Saracenic pottery (called Hispano-Moresco ware, when made in Spain) was the introduction of the oxide of tin in the glaze, to render it opaque. Previous to this innovation, when white was required for a design executed on a clay which did not take that colour in firing, these parts had to be covered with a silicious mixture, and subsequently coated over with a transparent glaze. This was the Assyrian and Persian process. To find a white opaque enamel, which could be applied direct on a coloured clay and adhere firmly to it, was a great discovery.

Everyone now knows how successfully these people used pottery for the ornamentation of their buildings, and how ingeniously they mixed transparent and opaque enamels to obtain an unprecedented harmony of effect. Not only did they use this tin enamel in parts, but also all over the ware, making it more or less opaque as they wished, and this was the origin of the pottery called *majolica*, which, according to tradition, was imported from Majorca, to Italy, at the beginning of the fifteenth century, and for the introduction of which credit is given to Lucca Della Robia. *Terra in-vitriata* was the first name given by this sculptor to his works, when they were coated with this opaque mixture. There was at that time such an earnest desire to find suitable materials for art decorations, that the new *enamels soon* ceased to be exclusively applied to archi-

tectural purposes. Under the beneficial influence of the revival of taste for ancient art, and the encouragements with which it met from the princes at that time ruling the Italian Republics, majolica attained its beauty, though its external appearance reminded us but little of its Spanish or Oriental origin. During the course of the fifteenth and sixteenth centuries, the most famous in the history of modern art, the influence of the great painters of that period was soon felt by those whom we may call the artists of pottery, for the name of potters could hardly do them justice; and several of them applied their talents to the reproduction, on that ware, of their most celebrated paintings. It was reported that Perugino, Michael Angelo, Raphael, and many others, painted majolica ware, probably on account of their cartoons being often reproduced; and it is sufficient to say that such talented men as Francisco Xanto da Rovigo, Orazia Fontana, and Gorgio Andreoli, devoted their energies to the improvement of this branch of art. Most of the Italian towns had their manufactory, each of them possessing a style of its own. Beginning at Caffagiolo and Deruta, they extended rapidly to Gubbio, Ferrara, and Ravenna, to be continued to Casteldurante, Rimini, Urbino, Florence, Venice, and many other places.

After the sixteenth century, majolica soon degenerated in appearance and quality, the producers being more anxious to supply the market, than to devote to their ware the care and attention bestowed on it by their predecessors. In increasing the quantity of tin in their enamel, to make it look more like *porcelain, they* impoverished their colours, and this

alteration, however prejudicial to majolica, assisted greatly in the new transformation which it was subsequently to undergo. It was under the name of faïence that it continued to be known, and France and Holland became the principal centres of its manufacture. At Nevers it still resembled slightly the Italian ware, though at Delft, in Holland, it was principally made to imitate the blue and white ware of the Chinese, in which attempt the makers were often remarkably successful. At Rouen the blue ornamentation was relieved with touches of red, green, and yellow; at Moustiers the monochrome designs were light and uncommonly elegant; at Paris, Marseilles, and many other places, the flower decoration of the old Sèvres and Dresden ware was imitated with a freedom of touch and a freshness of colour which is really charming. This pottery, which was a great favourite in the seventeenth and eighteenth centuries, declined rapidly soon after our present earthenware made its appearance; the chief inducement for the change, on the part of the manufacturers, being the excessive price of tin, which is the chief ingredient of enamel.

Except in the provinces contiguous to France, Germany was never a producer of majolica. It created, however, a pottery entirely of its own, full of originality in its general appearance, and which, by the peculiarity of the process, was really a very distinct type. I am alluding to the Flemish and German stoneware. There is a tradition, that the first pieces were made in Holland at the very beginning of the fifteenth century. The *principal centre* of its production was, however, in

Germany, at Nuremberg, Ratisbon, Bayreuth, Mansfeld, and other places; but the best were made in the neighbourhood of the Lower Rhine, where the clays most fitted for that class of pottery were easily to be found. Here we find, for the first time in Europe, the body of the ware partly vitrified by the high temperature to which it was submitted, and also the remarkable peculiarity that it was glazed by the volatilization of common salt, thrown into the oven when the temperature had reached its climax. The combination of these two processes had never been effected before, and it would be difficult on that account to find any connection between stoneware and some of the Egyptian potteries. This stoneware varied in colour: some was almost white, some brown, others of a light grey, the last being the most valuable when the effect was increased by blue or purple grounds, harmonizing admirably with the foundation colour of the ware. The shapes are generally elaborate, with a great many mouldings, enriched with embossed ornaments in good taste, some of which were designed by no less an artist than T. Hopfer. The decline of this stoneware began with the seventeenth century, and from that time to the present this material was only used for wares of the commonest kind. It is only very lately that it was revived successfully by Messrs. Doulton and Co., of Lambeth.

France, which had not as yet any ideas about the process for imitating the Italian majolica, created towards the same time two new sorts of pottery, one of which is the Palissy ware, the other the faïence *d'Oiron.* Palissy, a very inquisitive and intelligent

man, is said to have been possessed by a strong desire to reproduce some Italian ware, which he had the opportunity of seeing; whether it was a piece of majolica or of graffito is not known. Left to his own resources—for there was nobody to instruct him—he succeeded by perseverance and industry in finding out the process for making the different coloured glazes, that the Moors had used long before him. There was no discovery in this, but the talent which he displayed in the mixing and blending of these vitreous colours, combined with the incontestable originality of his compositions, have made this ware very difficult to imitate.

The time of its production was limited to the life of Palissy, for there is not really a single good piece which can be traced to his successors. In the faïence d'Oiron, incorrectly called Henri Deux ware, we find a real cream-coloured earthenware taking precedence of two hundred years over our own. It was made between the years 1524 and 1567, and we have now every proof that three persons co-operated in this invention: Heléne de Hangest, who had been formerly entrusted by François I. with the education of his son, afterwards Henry II.; her potter at Oiron, named François Charpentier; and her secretary, Jehan Bernart. The charming pieces resulting from the combination of these three intellects were few, and only intended to be offered as presents to the friends of the noble lady at court. This sufficiently explains the monograms and devices, which are found associated with the elaborate ornaments *profusely* spread over their surface. No ware was ever made before or after this, which required

more care and delicate manipulation, and this explains why the highest prices paid in our generation for an article of pottery have been freely given for several of these curiosities. Their principal feature consists in inlaying differently coloured clays one into the other, a process not quite new, as it had been extensively used in mediæval times for making encaustic tiles for the flooring of our churches, but they were so minutely and neatly executed, and the designs so well distributed, that they are justly considered as marvels of workmanship. In speaking of these faïences d'Oiron, we can hardly admire sufficiently the variety in the productions of this period of the renaissance; and if we select four of these specimens, such as a piece of Faenza ware, one of stoneware, one of Palissy, and another of Oiron, they may fairly stand as good illustrations of the ingenuity of man.

The progress realized in these times seems to have undergone a sort of lull, and if we except the French and Delft faïences, which were a transformation of majolica, we find that the greatest portion of the seventeenth century was not marked by any new discovery or decided improvement. Towards its close, however, we begin to notice in Germany and the western countries of Europe several attempts at making a ware, possessing the three standard qualities of whiteness, hardness, and transparency of the Chinese, and these were the precursors of the great movement which occupied the whole of the eighteenth century. As might be expected, inquiries made in different countries by persons unacquainted with each other, brought

different results ; and if they failed in so much, that a porcelain identical to the Oriental was not reproduced, all of them succeeded in making a white ware of their own, adapted to the materials which they had at their disposal. And thus arose in each country the source of a prosperous trade.

It is only at that period that England began to take her position amongst the producers of pottery, at least in a manner deserving of that name. Up to that time, if we were to judge by the quality of her work, she did not seem fitted for it, no more than for any sort of manufacture which required taste or a certain knowledge of the arts of design. In fact, it is easy to notice in looking at our collections of art manufactures, that the English samples are deficient in many respects; they may be gaudy without harmony of colour, or elaborate without refinement, exhibiting a certain amount of roughness in execution when placed side by side with Italian, French, or German specimens of the same class. It is likely, with certain exceptions, that the Anglo-Saxon race did not feel much the want of all those niceties, and did not make great exertion to excel in the practice of those arts, for the appreciation of which its mind was not yet sufficiently cultivated. It has been remarked, that as the progress of art was constantly from East to West, the geographical position of England might account in some respects for her backwardness. However, like children of slow growth whose understanding does not seem quick or acute, but who afterwards derive the benefit of their reserved strength, England, coming almost the

last in the production of pottery, seems as though she did so for maturing her capabilities. In this, as in the practice of other arts, she is slow, and her first steps are clumsy. Experimenting for some time, with mixed or indifferent success, she seems to hesitate till she begins to feel that she holds the thing in her grasp, and then [illegible] comes when she teaches the world what she can make of it. We [illegible] scarcely give her credit [illegible] Staffordshire pottery made [illegible] glazed with the [illegible] Derbyshire mines, the [illegible] pouring the [illegible] in a [illegible] manner. This pottery was [illegible] the time of Queen Elizabeth [illegible] the date of the [illegible]. Some pieces preserved [illegible] the Museum of [illegible] are to be [illegible]

[illegible] than [illegible] have [illegible] that [illegible] Museum of Practical [illegible] that so far back as 1601 [illegible] glazed

the dimensions and quality of earthen vessels manufactured at Burslem for holding the butter brought to the markets.

Towards 1680 a radical change seems to have taken place in the way of making the ware, by substituting common salt for the galena in the glazing process. This new production was called *crouch ware*, and there is every probability that the substitution was first made by a person acquainted with the manufacture of the German and Flemish stoneware, which at a former period had been tried in England. At that time Burslem possessed twenty-two ovens, and Plot says, that when these were at work, the vapours emanating from the salt were such as to produce a dense fog in the town. These assertions leave no doubt as to the date of the commencement of this manufacture in Staffordshire, and that Burslem was its first seat.

Two German brothers, of the name of Elers, who settled near this town in 1688, seem to have been the first to try to produce pottery of a better class than the crouch ware. Their first attempt resulted in the production of a dense and sometimes highly polished red stoneware, which probably resembled the red ware made in Saxony by Bottger at the same time. Those who have left any written information about it, say that for general appearance and careful execution it was quite equal to any similar article made by the Chinese. These foreigners paid also great attention to the improvement of the white ware, and they were the first to employ the plastic clay from Dorsetshire for the purpose of whitening the cane marl of the locality. Their

ware was generally light and well shaped, and though the plaster moulds were unknown at the time, and were only introduced fifty years later, the impressions taken from metal moulds are neat, and show the ornaments standing sharply out from the surface. This, combined with the peculiar appearance given to the surface by the sublimation of the salt, and its light colour, are the principal features of the Burslem ware, which continued in existence till 1780, although before that date more perfected articles had found their way to the market. The brothers Elers used to make a great secret of their mixtures, and left the district as soon as the other manufacturers became acquainted with them. Astbury, who had been instrumental in robbing them of their processes, was one of the most intelligent amongst these potters, and it was he who, in 1720, introduced the flint, calcined and ground, for whitening the body of the ware, one of the greatest improvements in the making of earthenware. He seems to have been a thoughtful and persevering man, and it is said that the idea of this new material was suggested to him, by seeing a shoeing smith calcining a flint, for the purpose of blowing the dust in the eyes of a horse which was afflicted with a kind of blindness. This is probably only a fiction, as the idea must have originated from witnessing the change undergone by flint when brought to a red heat.

As the pottery trade was taking root in the district, it is no wonder that we find many intelligent manufacturers doing their best to improve it and make it profitable. Eminent amongst them was Josiah Wedgwood, whose

name as a potter is never likely to perish. For particulars concerning his private life, trade, and manufacture, there are two excellent books, by Miss Meteyard and Mr. Llewellyn, in which every matter of interest about him has been carefully entered. Born at Burslem, in 1730, of a family of potters, he began by serving his apprenticeship as a thrower under his brother, and must have settled in business very early, as he had had already two partners when he set up on his own account, in 1759, being then only twenty-nine years of age. His first attempts seem to have been directed to making a green ware, that is, a white ware covered with a glaze of that colour, which he succeeded in getting particularly bright; and also to the tortoise-shell, which had its surface mottled with glazes differently stained, and which, by their blending when they are fused in the oven, present some analogy with the works of Palissy.

One of Wedgwood's decided successes was perfecting the white cream-colour ware, which was so superior to anything done before, that it commanded at once a great sale at home and abroad. Queen Charlotte admired it much, and, in consequence of her patronage, it took the name of Queen's ware, under which it was known for a long time. It is light, of a pleasing colour, and elegantly shaped, and in the hands of artists has proved an admirable material to paint upon.

It would take too long to enumerate all the improvements which Wedgwood effected in his trade in the second half of the last century, but I must mention *as prominent amongst* his works, the black Egyptian

and jasper wares, in making which he had no assistance whatever, and which constitute two new and perfect types in pottery. From Wedgwood's origin and early labours, it is easy to guess that his instruction must have been limited; but he was a clear-minded and inquiring man, possessing that sort of intuition by which he could easily understand things, which in other people would have required preliminary studies; besides, he had a natural taste for art and a systematic way of going through his experiments, which were sure to bring them to a successful issue. It was his good fortune to be assisted by two men of superior intelligence, viz. Flaxman, the sculptor, who designed many of his shapes and modelled for him an almost innumerable number of subjects for slabs and cameos; and Thomas Bentley, a distinguished scholar, with whom he was commercially connected, and whose knowledge of art he found of great utility.

When Wedgwood died, in 1795, the ceramic manufacture had extensively developed, and had extended from Burslem to the small towns in the neighbourhood. From all this it must appear that although Wedgwood was the most brilliant type amongst the English potters of that period, the trade was already well established when he entered the business, and there was every probability that it would become one of the staple industries of this country. To give all the credit to him would be an injustice to several men, who, like the two Josiah Spodes, effected great improvements, or brought into use new and useful materials.

When I speak of the china manufacture, it will be

seen that, besides the Staffordshire potters, several very clever men at Bow, Chelsea, Plymouth, Worcester, Derby, and other places, were at work to establish the manufacture of the soft and hard porcelain, proving beyond a doubt, that most energetic efforts were being made to raise the pottery trade of England to the same level as that of France or Germany. If we did not then succeed in making soft china like that of Sèvres, or hard porcelain as good as the Dresden, we soon became the masters of the market as regards earthenware—a position that we are not likely to lose for many years to come. Amongst the circumstances which combine to make our position particularly strong, it is enough to mention our independence as regards the supply of the raw materials, and the abundance of our clays and fuel, of a better quality than those at the disposal of our competitors. Besides, the localization of this manufacture in Staffordshire has caused the concentration in this spot of an intelligent population, acquainted with the traditions, from which the different branches of the trade can be easily fed.

The soil of Staffordshire produces a variety of clays which are used for common ware; but the most important is the one called *marl*, which is fire-clay from the beds of the coal measures, used for making the "saggers," or clay boxes, in which the ware is placed before it is sent to the ovens. The quantity required for this purpose is very large, and it was of the utmost importance that such material should be good, cheap, *and easily procured.*

At present, however, the clays necessary to make china or earthenware are not found in Staffordshire, but are sent from the counties of Dorset, Devon, and the Duchy of Cornwall, where they constitute an important branch of commerce. It is a common occurrence to hear people, visiting Staffordshire for the first time, wonder at the apparently abnormal fact of an industry settling in a district where none of the requisite materials are to be found. I have mentioned in the preceding pages how it happened that the trade first settled in Burslem; and a short explanation will show that although more perfect clays from distant counties had to be used, there was no need to change.

For baking pottery the quantity of fuel required is comparatively large. When, independently of the ovens and kilns, we take into account what is absorbed by the steam engines, preparation of materials, and warming of the shops, we find that for every ton of manufactured goods, at least three tons of coals are wanted, and that for decorated goods it will take twice that quantity, and even more. As the districts from which the clays are sent have no coals, the advantage of paying the carriage on the smallest number of tons to be brought to the works becomes evident.

The potter's clay derives its origin from several felspathic rocks, which under various influences have been decomposed, and the finest portion washed away, to be collected in natural depressions of the soil, where it has formed beds of various thickness. Chemically speaking, it is a silicate of alumina in combination *with water*, with the addition, in small quantities, of

different materials, such as potash, soda, lime, or iron, acting as fluxes on the silicate, which otherwise would give no signs of vitrification. The iron, which may exist in different states, has a colouring effect injurious to the clay, which, to be useful, must be almost free from it. When this condition occurs, the excellence of the clay is determined by the quantity of alumina that it contains. Pure silica, in the form of quartz, flint, or sand, is a very easy material to procure when wanted, but as no geological formation yields alumina in the pure state, no other can be got, besides that which already exists in the clays. It is a common error to say that it is the silica which renders them refractory. It is true that pure silica can stand any amount of heat without fusing, but its readiness to combine with alkaline matter and form vitreous compounds, renders its use objectionable when heated with metallic oxides. An excess makes the wares brittle and unable to resist sudden changes of temperature, while alumina, on the contrary, gives these qualities, and with them the plasticity required for the working of the ware. From it the clays derive the property of absorbing and retaining a large quantity of water, and such is its affinity for it, that sometimes a red heat will hardly suffice to expel it completely. Alumina is a light material—silica a heavy one; and a potter ought to know approximatively in testing the density of a sample, whether it is rich or poor in either of the two. The reason, why the clay deposits are richer in alumina than the rocks from which they originated, is *explained by the* lightness of this element, which

being kept in suspension in water for a longer time was consequently carried farther, leaving the silicious refuse to settle on its way.

For earthenware or china, the English potters use only two sorts of clays: the ball clay, also called blue clay, and the kaolin. For porcelain the last only is used; for earthenware, both. The ball clay, exported from Teignmouth and Poole, comes from the lower tertiary clays of Devon and Dorset, and is remarkably good and plastic, the quantity of iron being comparatively very small. The ball clay from Poole is dug in the neighbourhood of Wareham, by Mr. Pike. It is of a very superior kind, and more than 70,000 tons are sent from that harbour alone to the potteries, besides smaller quantities to the Continent. As it possesses a little more alumina than those from Teignmouth, which are dug at Teigngrace and Whiteway, near Bovey Heathfield, they ought to have a little superiority over these, although in practice the difference is not always perceptible.

Kaolin is the Chinese word given to the clay from which hard porcelain is made, though here it is generally called China or Cornish clay. This material is found in some granitic rocks in an advanced state of decomposition; the felspar, their most important element, having under external influence lost the greatest portion of its alkali, and become converted into a kind of earth. By agitation in a large quantity of water it dissolves readily; the refuse, composed of quartz, mica, schorl, and undecomposed felspar, sinks by its own weight to the bottom of the tank where the liquid mixture is to

run; and the finest part, which is the kaolin, is carried farther to large receptacles, where it accumulates. When these are full, the clay is removed and dried for export. In that state it is very white, and although not so plastic as the ball clay, contains a little more alumina and less iron, which accounts for its resisting much better the action of fire. It is principally obtained at St. Stephens and St. Austell, in Cornwall; Lee Moor, near Dartmoor, in Devon, and a few other places; the whole of them sending to the potteries about 130,000 tons annually.

From the same districts comes another granite, in a less advanced state of decomposition, called Cornish stone, which is used fresh from the mine without further preparation. In it the felspar retains its alkaline element, so that it can be easily melted, and is found a useful and cheap flux for the vitrification of the various mixtures. The composition of these rocks varies considerably, so that it requires constant experiments to determine in what proportion the quartz and the fusible parts stand to each other.

Flints are also largely used in the manufacture of earthenware. They are found abundantly in the chalk districts, the brown sort being considered the best. Under a moderate red heat they become white and opaque, and may be easily crushed between iron rollers. In that state they are placed in pans of water and ground by large stones of chert, till they become sufficiently divided to remain in suspension in the liquid without sinking and hardening at the bottom of the tanks, which, by the way, are called "arks." Flints are

comparatively a cheap material, and their carriage to Staffordshire represents a large portion of their cost.

Such are the four materials essential for making earthenware. The respective quantities in which they are used varies in each manufactory, but the principle is always the same: the ball clay being the foundation, and flint the whitening material; but as an excess of this would make the body difficult to work, Cornish clay assists in making it whiter and less liable to break under a heavy weight or sudden changes of temperature. The Cornish stone is used in a small quantity as a flux, to render the ware more compact and of a closer texture. When the mixture of these materials is completed, the colour taken by earthenware when fired would not be a perfect white; the quantity of oxide of iron existing in the clays, however small, would be still sufficient to impart a yellowish tint, particularly after the glazing of the ware. This is counteracted by the addition of a small quantity of oxide of cobalt, the power of which over the iron, as a staining material, is such as to neutralize it completely; the result, in fact, being the same as that obtained by washerwomen, who use blue to the linen with the object of making it look white.

From the moment that the materials are extracted to the time when the goods are perfected, the number of distinct operations to perform is so great, that I can only give a summary description of the most important. The grinding of those materials which are not already in a fine state of division is one of the most essential, *for upon it depends* the soundness of the ware, and

without it the difficulties of workmanship would be greatly increased. It must be so perfect, that when the different components are put together in the slip state, they should mix readily and form a homogeneous compound. The grinding for the use of potters is a trade of itself; but good quality is of such importance, that the manufacturers who can afford it prefer having mills of their own. In these the different materials are ground in water in separate pans, till they can pass freely through fine silk lawn, and are afterwards stored in distinct reservoirs, and the excess of water removed, so that a quart measure of each should weigh a determined number of ounces. As the potter knows beforehand the proportion of solid matter contained in each liquid measure, it only remains for him to count the number of quarts or gallons which must be introduced into the body of the ware. This being done, the liquid mass must be deprived of its superabundance of water. Till lately it was the custom to effect this by running the slip 10 or 12 inches thick over the surface of long kilns, paved with bricks and provided with flues underneath. The heat which was maintained in these, assisted by the porous nature of the bricks, was sufficient to bring it to the proper state of toughness; but the kilns could not be filled more than once a day, and required besides a large quantity of fuel, much of which was wasted in the form of dense smoke. Now, thanks to the new apparatus of Messrs. Needham and Kyte, the same result is obtained with great saving in space, time, and fuel.

The process is simple, and easy to manage. As soon

as the final mixture is sifted, the slip is directed to a well, whence it is raised by an hydraulic pump and sent to the presses, which are composed of a variable number of large wooden frames. These are closely ribbed on both faces, and, when placed side by side in a vertical position, they leave in the middle an interval of about three-quarters of an inch in thickness. Each of these hollow compartments is lined with a sheet of strong cotton stuff, folded in such a way as to form a bag, in the middle of which a small metal fitting passes through the upper part of the frames, and forms the spring by which the slip can be admitted into the interior. When the bags are tied together, the slip is admitted into their interior and submitted to such pressure from the pump, that the water filters through the interstices of the stuff, and escapes by the small intervals left between the ribs of the frames. After allowing a sufficient time for the action of the pump, the presses are dismounted, and the solid clay is found in the middle of the bags, ready for use in the various departments.

The processes for shaping the different articles are many. For the more expeditious preparations of the wares, it was necessary that each workman should devote the whole of his time to a special branch of his art. For this reason we have several classes of potters, called according to their avocation: throwers, turners, handlers, hollow and flat ware pressers, figure and ornament makers, tile makers, modellers, mould and sagger makers, besides those who are employed in the *decoration* of the goods. Of all these various branches, *the most attractive* for those who are witnessing it

for the first time, is the throwing; and it is a source of amazement for them to see how quickly, in the hands of the potter, the same lump of clay can be transformed in a variety of ways.

The potter's wheel is of great antiquity. In some Egyptian hieroglyphics from the tombs of Beni-Hassan, known to have been made during the twelfth dynasty, the different occupations of the potter are painted with great distinctness. In one of these, two potters are using the wheel for making their vessels—implying that this contrivance has been in use for something like four thousand years. The forms and proportions of the wheels may be varied without altering the principle. A spindle, finished at its lower end in the form of a pointed pivot, is placed on a hard substance on which it can easily revolve. The upper end is furnished with a wooden head or small platform, on which the lump of clay is to be placed, and between this head and pivot is fixed an horizontal wooden disc of large diameter, which acts as a fly-wheel and keeps the spindle in motion for a certain length of time. The motion may be given by the hand, the foot, or mechanical power, which causes the spindle to revolve with great velocity. A good thrower requires a great deal of practice, as he is expected to throw several hundred pieces a day, although the art is far from being what it was in the olden times. In consequence of the new plan of pressing all large pieces in plaster moulds, the thrower has but small or moderate size pieces to work, and these he finishes only in the inside, leaving the outside to be done by the turner, when the

pieces are in a more advanced state of dryness. This division of work, brought about by the exigencies of the trade, is very much to be regretted, for the old thrower was really an artist who could impress his feeling on the work which was entrusted to him from beginning to end. He has not now the same opportunity of showing his skill, and cannot take in his work the pride and interest which he would have felt if circumstances had not been altered. The same may be said of the turner, who finishes the outside on a lathe like that used for turning wood. The thrower prepares the pieces of a thicker bulk than is required, and it is the turner's business to bring them to a proper thickness by removing the excess of material and giving to the exterior a smooth and highly finished surface. If the handles are ornamented, they are pressed in plaster moulds; if plain, they are squeezed from a brass cylinder, filled with clay, with a small aperture at the bottom, from which it escapes under the pressure in long ribbons. These are placed side by side on a board, cut across at the required length, and bent in the form of handles when they get sufficiently hard. They are afterwards fitted, and made to adhere to the pieces by means of a little water or slip dropped from the point of a brush.

Flat pieces, such as plates, dishes, saucers, and the like, are made in plaster moulds, on which a bat of soft clay is tightly compressed by a hand tool, called a polisher. The process is very expeditious, although the presser *is obliged to* repeat the operation twice, to give more *pressure and finish.* For this kind of ware the potter's

wheel, called a jigger, is simplified so far, that the iron spindle resting on its point and fixed to a bench, is provided only with a round plaster head on which the moulds are placed. The presser keeps this in motion with his left hand, whilst with the right he guides the polisher.

In those manufactories which have adopted the latest improvements, the jiggers are worked by steam power, and the stoves in which the pieces are sent to dry are heated by steam pipes. These are constructed on a new principle, consisting in a number of shelves which revolve round a central spindle, so that by a gentle push of the hand, each section is successively brought in front of the door, giving the opportunity of removing or putting in the moulds. This simple contrivance does away with the necessity for the assistant boy entering the stove, and feeling the bad effects of the heat.

When the pieces are not exactly round and cannot be thrown or pressed on jiggers, it is the custom to have them made in plaster moulds, which have been cast on models prepared for the purpose. As long as the clay keeps soft, it takes the shape of any hard substance against which it is pressed, and for that reason, plaster, which has the property of absorbing moisture readily, is preferred. The use of plaster for moulds is comparatively recent, and although its properties were known in early times, there is no evidence that it was ever employed for that object. Greeks, Etruscans, and Romans, had their moulds made of fired clay; the Chinese, in raw clay thoroughly dried. In

Staffordshire, before the use of plaster, they were made of fired clay or metal; but plaster is more economical than any of these, although moulds made of this material do not last long, and require constant renewing.

The making of moulds, well adapted for pressing the various shapes, is a very important part of the potter's business. They must allow of a certain amount of contraction, and, at the same time, must easily dislocate without pulling away any part of the piece, which is still sufficiently soft to be distorted by careless handling. Some pieces will require moulds made in one or two parts; others, a large quantity of them, the various fragments being in that case pressed separately, and carefully put together afterwards. The pressing is done in this way: the potter begins to flatten a lump of clay in the form of a bat, and transfers it to the inside of the mould; then, by the repeated blows of a sponge in his right hand, he compels the soft material to take the exact form of the mould, and, of course, of any ornametation which may be on its inner surface. A good presser ought to be systematic in his work, and not to apply more pressure to one part than to another, otherwise the different portions of the pieces would not contract alike, and would be liable to show an irregular surface, or even crack in the drying or firing processes.

For several reasons there are pieces which cannot be pressed: they may be required very thin, or their shape is such, that the potter cannot reach all the parts to take the impression conveniently. In this case he must adopt the following plan. The mould is tied up and

filled with liquid clay through an opening left in the top. The plaster rapidly absorbs the water and a deposit of solid clay adheres to the surface. This soon increases in thickness; and when the potter thinks it is sufficient, he pours out the slip which is in excess. The piece soon hardens, and when it begins to contract, it is then time to remove it from the mould. This process has the advantage of giving a uniform thickness, and as there is no other pressure than that caused by the absorption of the plaster surface, there is a better chance for the piece to contract equally, and on this account this method (called *casting*) is preferred for articles which require a neat execution. In some cases it is cheaper than ordinary pressing; but the drawback is the excessive contraction or diminution of bulk, to which the ware thus made is subjected. An irregular contraction is the source of most of the defects attending the ceramic manufacture, and it is worth explaining the causes, of which there are three. I have already mentioned that natural clays, which have remained in a damp soil for ages, contain materials in a hydrous state, i. e. combined with water, which sometimes increases their bulk considerably. These are unstable compounds, and may be destroyed by thoroughly drying them. Some other materials used in potting may be artificially combined with water, as would be the case if ground in it for an unnecessary length of time. The second reason is the interposition of the uncombined water between the solid particles of the clay, and as this cannot be worked without it, this cause of shrinking *cannot be avoided.* It will be easily understood that

when the water in the mixture evaporates, the solid particles, under atmospheric pressure, will move to take its place, and this effect will continue as long as they find enough moisture to assist in their free motion. The consequence is, that the mass shrinks more and more, till the contraction is stopped by the inability of the particles to move farther; and this happens before the pieces are completely dry. From that state to complete dryness, the evaporation of the remaining water will leave small holes, which will make the texture of the ware porous, and prone to absorb any liquid with which it may come in contact.

The shrinkage in the raw state then is mechanical, and distinct from that which takes place in the oven under the influence of heat. Under this agency the particles enter into combination, and if the process is carried far enough, the ware may become partially vitrified and acquire a certain amount of transparency. The more perfect the vitrification, the closer will be the contact of the particles, and consequently the greater the diminution of bulk. From these causes, the total contraction may vary from one-sixteenth to one-fifth of the original model. The least will belong to ware pressed with stiff clay gently fired; the greatest, to that cast with liquid slip and brought to the vitrified state. In these last the shrinkage is greater in height than in width, a fact explained by the weight of the upper portions acting vertically to assist the closer contact of the particles in the under-structure, when the same opposes their free action in an horizontal direction. In making the models, care should be taken to

bring the contraction to a common centre, or if there are several, to strengthen sufficiently the connecting parts.

After the drying of the ware, the next operation consists in placing it in saggers, which, as I have said, are made of common fire-clay, and of a form and size to suit the different articles which they are intended to hold. A certain thickness of flint or sand is placed at their bottom for the purpose of giving them a firm bed, and as it is the interest of the manufacturer to make the same firing answer for the greatest quantity of goods, care is taken to fill the saggers as far as is safe. The placing of the ware is done at the outside of the ovens, and when these are to be filled, the saggers are quickly arranged one over the other in columns, called "bungs," each sagger forming the cover for the one immediately underneath. A small roll of soft clay placed between makes them stand better, and at the same time prevents the ashes carried by the draught from finding their way into the interior, and damaging the contents.

In ancient times, the ovens, intended to hold few pieces, were very small; but as the potters became more experienced, the sizes were gradually increased, and now-a-days some of them are not less than 19 feet in diameter. The quality of fuel had, of course, a great deal to do with their mode of construction. Now, however, that coals are acknowledged to contain more heat, and to be cheaper than wood, the ovens are generally built in a cylindrical form, with several mouths or feeders disposed at equal distances on the *outer circumference*, the upper part being covered by

a semi-spherical dome or vault, to keep the heat inside and reverberate it downwards. This construction is very simple, the only complication being in the arrangement of flues under the bottom of the oven, so as to throw into that part a portion of the heat, which otherwise would be liable to accumulate towards the top.

The firing must be conducted very slowly at first, to prevent a too sudden evaporation of the damp, which would cause the splitting of the goods. This being done, the heat is raised gradually, care being taken to feed the mouths with fuel as quickly as it is consumed. It requires an experienced fireman to see that one part of the oven does not get in advance of the other. He manages this by throwing in a certain quantity of air through small openings in the brickwork, which are shut or left open according to circumstances. Whatever may be the construction of the oven, the quantity of air mixed with the gas produced by the combustion of fuel causes the atmosphere to be reductive of oxidizing; which means that the different materials submitted to the heat would, in consequence of an abundance of carbon, have a tendency to be deprived of their oxygen and return to a metallic state, or that by firing in presence of an excess of air or carbonic acid, they would be kept in a high state of oxidation. It is fortunate that all classes of English pottery, without exception, require, or are not injured by, an oxidizing fire, which is the most economical way of firing, since by it all the gases are completely burnt inside the oven without any waste of fuel. By a better application of *this principle*, Messrs. Minton have introduced a new

oven, in which the fuel is so completely utilized, that it requires only one-half of the usual quantity of coals, besides doing away with the dense smoke which is the annoyance of the district.

By the first fire to wh[illegible] it is exposed, the ware is converted into [illegible]d, from the French, *biscuit* —an incorrect [illegible], as it seems to imply that it has already been fired twice, when, in fact, it has been only fired once. Some classes of pottery do not require more than a single firing, as, for instance, the common terra cotta and stoneware. However, for all our English ware it is necessary to have two fires, for the following reasons: First, the necessity for getting a denser texture of the ware by submitting it to a strong heat, lest the glazes which are to be melted on their surface, and which thereby become very dense and most contractible, should not agree with the more open texture of the body, and should crack or craze when exposed to changes of temperature. Secondly, that for coating the ware with the glaze, it is necessary to dip the article in the vitreous mixture finely ground, and kept in suspension in water; consequently, if it were in the raw state when this was done, the adhesion of the particles would be so small that they would readily dissolve in the liquid. It is customary, therefore, to expose the goods first to a hard fire, which, according to the size of the ovens and the quality of the ware, may last from forty to fifty hours.

From the biscuit oven, the goods, if they are to be left white, *may* be sent to be glazed; but if they are *to be decorated* with a printed pattern, they must be

forwarded to the printing department. Printing on pottery is comparatively a modern invention, its chief advantage being the cheap rate of production. Up to the last century the goods were always painted by hand: a slow, but, it must be confessed, a more artistic process, as the work executed in this way, even of an inferior kind, will exhibit a freedom of touch and facility of execution which will make it attractive and preferable to the formality of a printed pattern, however rich or complicated it may be. This superiority is sufficiently illustrated by comparing monochrome patterns of Italian majolica, Delft, and Chinese, with the modern printed ware of the same colour.

Public taste has so wonderfully improved lately, that, for my part, I have no doubt that we shall soon have a special class of artists trained to execute, by hand, cheap and simple decorations for those purchasers who are not satisfied with printed decoration.

To what extent the introduction of printing on pottery has hindered the progress of art education in Staffordshire, is a question on which people may entertain different opinions; but we might ask, what amount of artistic work we might not do, if at the present time we had some hundreds of artisans trained from their early years to that style of painting? However that may be, the process of transferring printed patterns to biscuit ware was considered a great step, and one which contributed largely to the extension of the earthenware trade.

Liverpool and Worcester claim the priority for this invention, towards the year 1752. It is a fact that shortly after that date, Staffordshire potters used to

send their wares to Messrs. Sadler and Guy-Green, of Liverpool, to be printed; and there is also every reason to believe that about the same time it was introduced at the Worcester works, then under the management of Dr. Wall, by an engraver named Hancock.

The process of printing on pottery does not differ very materially from that used for transferring to paper a design from an ordinary copper-plate. There are, however, these differences, that a metallic colour is used instead of lampblack, and that a fine tissue paper is specially made for that purpose. When that paper, with the pattern printed upon it, is laid on the ware, face downwards, the colours adhere strongly to the biscuit, which, being porous and aluminous, has a great affinity for the oil with which they have been mixed. After rubbing the back of the print with a roll of flannel, to secure the adhesion of every portion of the pattern, the biscuit piece is plunged in water, and the paper comes off quite freely, the whole of the colour sticking fast to the ware.

Previous to glazing, the printed ware must be brought to a red heat, for the sole object of burning the oil mixed with the colour. This is done in kilns, called *hardening-on kilns.*

The colours in use for printing under the glaze are not many; as few only of the preparations made with metallic oxides can, when brought to a red heat, stand the action of the glazes under which they are laid. Most of them in this case will be dissolved and considerably *weakened*, if they do not even completely *disappear. Cobalt*, and the preparations made from *chromates*, are the most resisting, and when well pre-

pared, the glaze in melting over them will bring out the colour with increased beauty.

The necessity for covering the biscuit with glaze to stop the absorption of liquids or greasy substances, which would find their way into its interior and would stain it, is so obvious, that I do not think it necessary to dwell on the importance of this operation. I have stated already that it was used by the Egyptians and Assyrians, who knew most of the saline mixtures by which white and coloured glazes could be obtained.

During the nine hundred years which may be counted between the revival of pottery by the Arabs and the introduction of well-made glazes by our Staffordshire potters, the last glaze in existence was that obtained by the grinding or pounding of the natural sulphide of lead, called galena. It is with this single material, stained with metallic oxides, that the Arabs glazed their rich-looking pottery, and the same was used afterwards for our encaustic tiles and our common pottery, from the time of Elizabeth down to the middle of the last century. Lately, however, the science of making glazes has considerably improved, and a variety of new substances has been introduced. To prepare a glaze is one of the most delicate operations possible, and failures are attended with most serious consequences. The conditions to be fulfilled are many. It must not be too fusible nor too hard, either of which conditions would make it dull or apt to craze; and it must be transparent, otherwise the colours underneath would not be clear. It may happen that a glaze which apparently seems good when it comes out from the oven, will craze when a few months, or perhaps years,

have elapsed. Generally, the less alumina that there is in the biscuit, the easier is the adaptation of the glaze, and this accounts for the soft porcelains being easier to manage in this respect than ordinary earthenwares.

The materials used for the *foundation* of glazes are in principle the same as those for the body, viz. silica, in the form of flint, or sand and felspar, pure or mixed with other components in the granitic rocks, called Cornish stone. These are the hard materials to be vitrified by the fluxes, which are carbonate or oxide of lead, boracic acid or borax, potash or soda, carbonate of lime or barytes. There is no definite receipt for mixing, and they may be combined in a variety of ways. Every manufacturer has receipts of his own, and I must say that some make their glazes a great deal better than others. They are rather expensive, chiefly owing to the increased price of borax, a material of comparatively modern use, which, being apt to promote the brilliancy of the wares and the beauty of the various colours, is now extensively used. When the components of the glazes are not soluble in water, it may be sufficient to have them finely ground in water. But if any soluble salt, such as borax, nitre, or soda, is employed, it is necessary to render them insoluble by vitrifying them together with other substances. This may be effected in crucibles, or, still better, in reverberatory furnaces, where a large quantity may be melted more conveniently. In this case, when the mass is well liquefied by the intensity of the heat, it is run into cold water, which, cooling it suddenly, causes it to break into small fragments. This is called a *fritt;* and when it is sent to the mill, any

other insoluble material may be added to it if necessary. To lay a thin coat of glaze on the surface of earthenware is a most expeditious process. Advantage is taken of the porous nature of the biscuit, which, being dipped in the liquid slip, rapidly absorbs the water, while the solid particles of the glaze, which, however fine, could not follow the water to its interior, are found coating the surface. As the pieces are removed from this bath before the pores of the clay are saturated with water, they are seen to dry almost directly.

After this, the last operation consists in firing the pieces a second time, to give them that neat and finished look which belongs to glazed substances. The saggers, ovens, and the mode of conducting the fire do not differ in this case from those used for making biscuit. The ovens are, however, smaller, and the saggers cannot be packed so closely with the different articles, as every piece has to be isolated, otherwise the glaze in melting would cause them to stick together. To provide against this, small implements made of clay cut in different forms are used, and, not to disfigure the ware, are contrived in such a way that the points of contact between them and the pieces should be as small as possible. This second firing does not take more than fifteen or eighteen hours, and this completes the series of operations by which ordinary earthenware may be produced.

The first earthenware made after the time of Wedgwood and Josiah Spode was far from being so good as the present one, and several attempts were made to *bring out* a pottery which should be intermediate

between earthenware and porcelain. The most successful was that made by Mr. Mason, of Fenton, who, in 1813, got a patent for an ironstone china, the body of which was fluxed by the scoriæ of ironstone and the ordinary Cornish stone. But afterwards this last was found sufficient for that purpose. The name of ironstone remained to that class of pottery which is strong and resistive. Since then, however, earthenware has so much improved that ironstone has gone out of fashion; the nearest to it is the ware called *white granite*, used in the American market, which is richly glazed, and made thick to compete with the French hard porcelain, that is also exported to the United States for the same class of customers. About fifty manufactories are specially engaged in producing this ware; and those in the occupation of Messrs. Meakin, Shaw, Bishop and Powell, and G. Jones, may be considered the largest. The best earthenware is made for the home market, some of which is so perfect that if it were not opaque it might be mistaken for porcelain. When it is richly decorated and gilt, like that made by Messrs. Minton, Wedgwood, Furnival, Copeland, Brown-Westhead, Brownfields, and several other leaders of the trade, very high prices are obtained for it.

Some of these makers do not devote all their attention to earthenware, but produce other classes of pottery. Amongst the sorts which are most connected with earthenware are majolica, Palissy, Persian ware, and flooring and wall tiles. I have given the name of majolica to that class of ornament whose surface is *covered with opaque* enamels of a great variety of

colours. It is only connected with the Italian or Moorish in this respect, that the opacity of the enamels is produced by the oxide of tin; but as we have not in England the calcareous clay for making the real article, we have been obliged to adapt as well as we could the old processes to the materials at our disposal.

At present, English majolica is very popular, and without a rival for garden decoration, as it stands exposure to the weather better than ordinary earthenware, besides the impossibility of the latter receiving the opaque enamels without crazing or chipping.

Majolica was produced for the first time by Messrs. Minton, in 1850, and they have been for many years the only producers of this article. It is only five or six years ago that Messrs. Maw, of Broseley, in Shropshire (and very lately the Worcester manufactory), who have made a pottery of the same kind. The name of majolica is now applied indiscriminately to all fancy articles of coloured pottery. When, however, it is decorated by means of coloured glazes, if these are transparent, it ought to be called Palissy ware, from the name of the great artist who used these for his beautiful works. Messrs. Wedgwood, George Jones, and a few other makers of less importance, are reproducing it more or less successfully. To Messrs. Minton, however, we owe the revival of the ware, which, in connection with their majolica, created such a sensation in the French International Exhibtion of 1855; and credit must be given to these gentlemen for being on that occasion the promoters of that demand for *artistic pottery*, which has so largely devoloped in these

last years. It is to satisfy the craving for novelties that they have undertaken the imitation of the faïence d'Oiron, better known by the name of Henri Deux ware, a rare and costly one, which can only be produced in small quantities; and also their most recent improvement, the reproduction of the Persian wares.

In the old Persian pottery we find a real earthenware taking a precedence of several centuries over our own. There is little doubt that it can be connected with the early Arabian, Assyrian, and Egyptian, by the similitude of the processes common to all. I have no room to explain how it is that, being an earthenware, it is so much richer in colour than the modern ware made on this side of Europe. I can only mention that the body of the Persian ware may be converted into a transparent porcelain by firing it hard, which shows that the sandy clays from which these are made are sufficiently saline to become vitreous. To this they owe the property of receiving, without crazing, glazes of the softest kind, and consequently of exhibiting those colours which can only stand at a low temperature, such as the Persian red, the turquoise, and that purple or violet which makes so valuable the specimens on which it is laid. If we had in England sandy clays like those which abound in Persia, the reproduction of Persian ware would have been an easy undertaking; but in trying to reconstitute it by synthesis there were several obstacles. Within the last three years, however, Messrs. Minton have sold a great many specimens of the ware, some of them of very large size. They may be recognized by the depth of the turquoise,

which is sometimes as rich as Sèvres pieces of the best period. Their only competitors for this class of pottery are the manufactories of Worcester and of Messrs. Maw and Co.

I cannot leave earthenware without mentioning the manufactory of plain and encaustic tiles, which forms an important branch of our ceramic trade, and with which the name of Herbert Minton is closely associated. It was during his time, and with the assistance of Mr. Michael Daintry Hollins, that this great undertaking was carried out with such success, that hardly a new church or public building is erected where these tiles are not introduced. The making of tiles is new and peculiar. The plain tiles are made from dry clay reduced to dust, which, being submitted in metallic moulds to a pressure of several hundred pounds to the inch, becomes so compact, that further contraction is almost suppressed, and they can be handled without risk of breaking. Encaustic tiles are made from plastic clay in which the different portions of the design are sunk below the surface, so as to form recesses in which slips of different colours are poured according to a set pattern. When these become as hard as the body of the tiles, the surface is made smooth and level with a steel scraper, which removes all the superfluous material, till the colours are shown standing neatly side by side with the greatest precision. It is a pretty process and interesting to witness. Besides the flooring tiles, there are many sorts made for lining walls and fireplaces, varying considerably in style and material. Mr. Hollins has built extensive works at Stoke,

in which he has introduced all the modern improvements. Messrs. Minton, Taylor and Co., of Fenton, and Messrs. Maw and Co., of Broseley Works, are his closest competitors. Messrs. Minton, of Stoke, still produce their decorated wall tiles, those specially artistic being painted by hand, at their art studio in Kensington. Messrs. Sympson, decorators, in London, are well known for similar productions; and Messrs. Copeland, of Stoke, for their painted slabs.

The various porcelain biscuits known under the name of Parian or statuary biscuit, are specially used for statuettes, busts, and other articles for which it is desirable to get the appearance of white marble. This is a kind of hard porcelain made from a mixture of kaolin and felspar, in which the degree of hardness or fusibility is regulated by the proportion of one material towards the other. Of course, similar biscuits may be made by more complicated receipts, but the principle is always the same, viz. the taking advantage of the fusibility of felspar or Cornish stone, to secure the required amount of transparency. The light being allowed to penetrate to some depth below the surface, imparts to these biscuits a softness which is wanting in the similar productions of Sèvres, Germany, and Denmark.

In noticing the bluish-white colour of the foreign article as compared with the cream tint of our own, I must explain that this difference lies in the management of the fire, since in none of them is stain or colour introduced to procure any such result. As my readers must now understand, there is in all clays,

pure as they may be, a certain amount of oxide of iron, which during the firing process forms silicate of protoxide or peroxide, according to the chemical composition of the atmosphere of the oven in which they stand. On the Continent, to make hard porcelain successfully, the fire must be reductive; while here, on the contrary, it is oxidizing; and it is to the formation of a small quantity of silicate of peroxide of iron disseminated in the mass, that the creamy colour of our Parian is due. Since this new material was introduced by Messrs. Copeland and Messrs. Minton, about twenty-eight years ago, a large quantity of figures, busts, and groups have been sold, and the talent of our most eminent sculptors has been put to contribution to get models adapted for this kind of ware. Parian is generally cast, which accounts for the great contraction it undergoes when fired, and much care is required for propping or supporting the various articles, as neglect or miscalculation in this respect would inevitably ruin them. Otherwise, as this biscuit is made from few materials and takes one single firing, the simplicity of the manufacture has induced many small makers to undertake it—a fact that we should regret, if we were to take a purely artistic view of this subject. Parian, which was originally sold in biscuit state, has since been glazed, for the purpose of making pieces of decoration. The manufactory at Worcester, several years ago, made a great many coloured and gilt ornaments in the Cinque-cento style, to which it has lately added a highly artistic imitation of the Japanese lacquered ivories, for which great credit is due to the present director, Mr. Binns.

The Belleek manufactory, in Ireland, has obtained a name for coating its glazed Parian with an iridescent lustre, in imitation of a similar article invented by a Frenchman, M. Bianchon.

For richly decorated ornaments, the body of the Parian has been stained with success in many rich colours by Messrs. Minton, their last production in this class being a Parian combining the red colour of the terra cotta, with the advantages of a vitrified porcelain. Their most artistic ware is, however, their *pâte sur pâte*, in the production of which they have been assisted by M. Solon, an eminent artist, who left the Sèvres works to establish this branch of fine art in their manufactory. To carry on this process, advantage is taken of the transparency of the Parian body with which the figures or ornaments introduced in the composition are painted, or rather modelled. As they are laid on a ground of a dark colour, the softness of the shades in the thinner parts gives to the finished pieces a particularly beautiful cameo appearance. The effect may be compared to that of the Limoges enamels, when confined to the white colour. This process has a certain connection with that of Wedgwood for making his jasper ware; but there is this difference, that in the jasper the figures and ornaments are taken from clay moulds, and may be repeated to any extent, the talent of the artisan consisting in pressing neatly and transferring on the vases the various fragments of decoration without destroying the sharpness of the impression, while in the *pâte sur pâte* original works can only be produced by the artist, *who must combine* the qualifications of designer and *modeller.* What I say here is not in disparagement

of jasper, which, considering the time of its introduction, was far in advance of anything that could be expected. In its production the Wedgwoods never had a rival, and the models of the celebrated Josiah Spode are still worked at their manufactory at Etruria, with the same success. The sulphate and carbonate of barytes were the fluxes originally used to vitrify the body of the jasper ware, and on this account it ought to be classified with the stoneware. Parian, which may be made from purely granitic materials, has a nearer connection with porcelain.

There are three different sorts of porcelain: 1. The Chinese and Japanese, with which may be assimilated the German and French, all of them made of kaolin and felspar, sometimes with an addition of quartz. The principal seat of this manufacture is now in France, with Limoges for its centre. 2. The soft porcelain, of which the most perfect type is the old Sèvres, includes those of Chelsea, Bow, Worcester, and Derby. In all these the transparency, which is the distinctive feature of porcelain, is secured by the introduction of *fritt*, a mixture of sand and alkaline materials thoroughly vitrified, ground and made workable by an addition of plastic clay. The calcareous marl used at Sèvres gave to the French works a superiority over the English, who could only use the clays from our southern counties. The manufacture of the soft porcelain, on account of its difficulties, is almost abandoned. 3. The English porcelain, the body of which is made, like the hard, from kaolin and Cornish stone, but differing from it by the addition of a large

proportion of calcined bones. This kind is exclusively English. For the hard porcelain, the glaze is made from felspar containing a variable quantity of quartz, or, as in Germany, from quartz vitrified by an addition of gypsum, the melting of which in both cases requires a very high temperature. For the glazing of the two other classes of porcelain, a soft, vitreous mixture containing silicate of lead and borates is used, the temperature necessary to melt these being much inferior to that required for firing the biscuit.

The most ancient porcelain is, as everyone knows, the Chinese, which, relying on the few authorities that have written on this subject, may have been in existence for two thousand years, and is said to have reached its greatest perfection towards the eleventh century of our era. The Portuguese have the credit of having been the first to introduce it in Europe, in 1520; but it is not improbable that, before they doubled the Cape of Good Hope, some specimens were brought to Europe through India and Persia. This may be inferred from the mention by ancient historians of some extraordinary white vessels, which could hardly correspond to any other kind of ware. The Portuguese and the Dutch, who were the first to explore the Chinese seas, seem to have derived a good trade from the importation of the porcelain into Europe, and since then the reproduction of that refined pottery was the ambition of many alchemists, who pursued their experiments in that direction with an eagerness almost equal to that wasted in the search for the philosopher's stone. For a long time, *in consequence* of the imperfection of their chemical

knowledge, their efforts ended in failure. The only successful attempt was that of Francis II., one of the Medicis, who produced a few pieces of soft porcelain, recognizable by their mark, representing the dome of Florence.

At the death of this prince, his secret was lost, and it was a long time afterwards, at the end of the seventeenth century, that John Dwight, a potter, of Fulham, in Middlesex, took a patent for what is curiously reported by Dr. Plot as "*the mystery of transparent earthenware commonly knowne by the name of porcelaine and Persian ware.*" Made from English materials, it is probable that this was nothing better than a kind of white stoneware, possessing little of those qualities which would entitle it to the name of porcelain. Next to that in date would be the soft porcelain made at the manufactory of St. Cloud, which was said to produce, in 1698, pieces of ware considered very good imitations of the Oriental. This was the origin of the French soft porcelain which was carried on afterwards with varied success at Chantilly, Vincennes, and other places, till it was definitely settled, in 1756, by King Louis XV. in the royal establishment of Sèvres. At a corresponding period, on this side of the Channel, the efforts of our potters were varied and numerous. If we are to believe Dr. Martyn Lister, a manufactory of porcelain existed at Chelsea as far back as 1698, a fact which would establish for England a claim equal to that of France for the discovery of the soft porcelain. This is not altogether improbable, considering that there was a glass manufactory in that locality before that,

and that many people had a notion that porcelain was nothing else than a glass hardened and made opaque. The managers of these glass works may have experimented on that supposition, and the conjecture is strengthened by the fact, that pounded glass was always used at Chelsea to give the desirable transparency. Good specimens are not, however, recorded before 1745, and it is probable that many of the improvements at Chelsea were realized by the Staffordshire potters, who, two years later, went there to apply their industry. The priority in making practically good ware belongs to the works established in 1730 at Stratford-le-Bow, from which the Bow porcelain took its name. It was not perfected there, however, before 1744, when a china, softer than that made at Chelsea, and nearer to that made at Vincennes, was manufactured by a potter named Frye, originally a painter, who seems to have been the promoter and manager of these works, which at one time did not employ less than three hundred people.

Bow was celebrated for its statuettes, and it is said that several of them were modelled by Bacon, the sculptor. The successes of Bow and Chelsea were great but of short duration, for both had ceased to exist in 1775, when their utensils and moulds were sold to Mr. William Dwesbury, and carried to Derby, where this enterprising gentleman had started a manufactory as far back as 1751.

Three generations of Dwesbury continued here the traditions of Chelsea, after which time the works became the property of Robert Bloor, the last owner of

repute. In that same year (1761), a man—who for his inquiring turn of mind and artistic knowledge seems to have a great likeness to Josiah Wedgwood—John Wall, a doctor and a chemist, began also to make porcelain at Worcester; and if Mr. Binns' assertions are correct as regards the preparation of the fritt used in it, he must have had some knowledge of the Vincennes receipts. The Worcester works have now been celebrated for more than a century, and with them must be associated the names of the various owners, Flight, Barr, and Chamberlain. At Caughley, in Shropshire, a manufactory of soft porcelain was in existence in 1756, and it was employed at one time by the proprietors of the Worcester works to assist in making ware, which was sent back to them to be decorated. The Caughley works were bought by John Rose, a pupil of Turner, the first director, and transferred to Coalport, with which the works of Nantgarw, in South Wales, were also amalgamated. At Swinton, in Yorkshire, soft porcelain was manufactured on the property of the Marquis of Rockingham. Manufactories also existed at Lowestoft and other places, so that the reader might here remark that all exertions to establish the manufacture of china were made outside Staffordshire; and if he has noticed the dates, he will also perceive that all these works were founded when Wedgwood was still too young to render any assistance. This we must say in justice to Dr. Wall, Frye, Dwesbury, and Cookworthy—whose name must not be forgotten as the discoverer of the Cornish clay, which so greatly promoted the ceramic trade of this country. William Cookworthy was a chemist and

druggist, at Plymouth, a member of the Society of Friends, and a man of great respectability. Having had the opportunity of seeing some kaolin and felspar from Virginia, that an American friend had shown to him as the very material from which the Chinese porcelain was made, he recognized, several years afterwards, the same in Cornwall, and setting resolutely to work, he began to make his first trials at St. Stephens, on the property of Lord Camelford, and afterwards at Plymouth, where he remained till 1774, when Champion, a merchant of Bristol, bought his patent, and removed the works to the latter place. I must here explain that Cookworthy's ideas of the making of porcelain were correct, inasmuch as he wished to closely imitate the Chinese; consequently he had to work on different principles from those then in favour at Chelsea and other places. He wanted to produce a porcelain without fritt and with a felspathic glaze, and in succeeding in his attempt this energetic man is entitled to a great deal of credit, when we consider that, although the processes discovered by Bottger, in 1710, at Meysten, for making hard porcelain, were also put in practice at Vienna, St. Petersburg, and Berlin, they were kept very secret, and it is most probable that he had no information whatever from those quarters. Most of the pieces of his manufacture were copied from the Chinese, and are still well known by the name of Plymouth porcelain. At Bristol, Champion used the same clay to produce a softer kind of ware, and his materials began to be employed at Bow and other places. The Staffordshire potters soon became anxious to take

advantage of the discovery, and in 1777 a company was formed by Jacob Warburton to get a licence for their use. This was granted by Champion, but with this singular restriction—that, although they were allowed to use a certain quantity of china clay and china stone, they were not to make porcelain. This restriction, however, did not last long, and Champion himself came for a short time to Shelton to superintend some works. Amongst the names of Warburton's associates, we notice some well known in Staffordshire, such as S. Hollins, of Shelton; Antony Keeling, of Tunstall; Turner, of Lane End, and a few others. To these gentlemen we must give credit for the earliest attempts to introduce the manufacture of china into the Potteries. However, their porcelain was inferior to that made at Worcester and Derby, and it is doubtful whether they would have persisted, if the matter had not been settled by Josiah Spode, the second of that name, who, by adding calcined bones to the body of the ware, made a new kind of porcelain, distinct from the hard or the soft previously made. On that account Spode deserves to be considered as the creator of the English porcelain. There is this peculiarity in the use of bones, that the phosphate of lime which enters into their composition is not decomposed by the silicates with which it is mixed, and, as it is infusible, its admixture in the body allows the ware to stand without injury the temperature at which the felspar is vitrified. This hardening of the bones does not exclude a certain amount of transparency, and they possess besides a very great advantage in

preventing the oxides of iron which, existing in the clays, produce that brownish or imperfect transparency noticeable in the old Derby or Worcester ware. I have already said that the adaptation of the glaze for each kind of pottery is one of the greatest difficulties that the maker has to overcome; in this case, however, there was very little, and the glazing of English porcelain may be considered as exceptionally easy. Most of the glazes which had been used for the soft porcelain could be adapted to this one, a property which was of great service when the pieces had to be decorated. It will be easily understood, that when paintings executed on the surface of the ware are submitted to a moderate red heat, if the glaze is soft enough to undergo an incipient fusion, the vitreous colours with which they are executed will sink into it and attain, by their incorporation, an amount of glossiness and brilliancy which cannot be got on the surface of hard glazes. This is particularly illustrated by the old Sèvres ware, which possesses this quality in the highest degree. English porcelain, well made, has almost all the advantages of the old soft, and its making is not attended with the difficulties experienced in working a body made from fritted substances. For regular use it is not much inferior to the hard porcelain. When this last began to be made on the Continent, people were so much prejudiced in its favour, on account of the capability of its glaze to resist the scratching of the knife, that this was thought to more than compensate for its inability to combine with the colours. The advantage was, in fact, more apparent

than real, for when hard porcelain has been long in use, it becomes as badly scratched as the English. Some people question whether it would not be desirable to revive in England the manufacture of the hard. There are many reasons against this, the principal being, that in case we succeeded, we should have to compete with the French and Germans, who get their labour cheaper, and have a long experience of processes altogether different from ours; and by the change we should lose the advantage of our traditions, and depend, at least for a time, on foreign labour to give a new training to our workmen. Out of the trade, few people seem to know that the price of hard porcelain is generally lower than that given for the English; and if the experiment were made, it would be soon found that with greater risks we should produce an article of less value, and consequently less remunerative. It is true that the exports of our best china are very small, on account of its price; but with the improvement going on in the public taste, it is likely to increase, and there are signs that eventually our richest articles may find purchasers on the other side of the Atlantic.

In Europe, where the value of the various ceramic productions has been more investigated than in the other parts of the world, there is hardly an amateur who does not recognize the superiority of a soft porcelain for decorated articles, and if the English china is not, properly speaking, as soft as the old Sèvres, it is certainly nearer to it than any other porcelain. Messrs. [illegible] father, the late alderman, was

for some time in partnership with Spode, occupy, in Stoke-upon-Trent, the same establishment in which that great potter carried out his improvements. Since then, these makers have kept their rank among the principal leaders of the trade, and maintain their reputation for the excellence of their decoration and the beauty of their gilding. It was so far fortunate for Stoke that, although one of the smallest towns in the potteries, it became the seat of the most important manufactories of china. It was in 1788 that Thomas Minton, who had been brought up as an engraver at the Caughley works, in Shropshire, and who in that capacity had been several years in the employment of Spode, founded in that town the establishment which subsequently became the property of his son, Herbert Minton. The father does not seem to have possessed these qualities which, as potter, should entitle him to a special notice; but the same cannot be said of the son, who soon after his father's death began to work in earnest to raise his manufactory to its present degree of eminence. The unceasing activity of his mind in carrying out improvements in all the branches of his trade, may be attested by one who for many years had the honour of working with him. On every matter connected with art his ideas were sound, and his natural tact rarely failed in finding out that which was most suited to the taste of his customers. His reputation, as the most advanced potter of his time, is so well established that I am not astonished to find others claiming a share in it, asserting that it was at their suggestion or with their assistance that he left the

old path to open the way to progress. Suggestions and advices are always freely given to a man of sociable disposition as was Herbert Minton, but he used his own judgment and discretion to test their practicability. In applying higher class of art to his productions he had only to follow his own inclinations, guided by that care and prudence which are inseparable from good administration. He knew how to select his assistants, and was particularly fortunate in his partners, his two nephews: Michael Hollins, who, since he left the firm of Minton, is the owner of a large tile manufactory at Stoke; and Colin Minton Campbell, his pupil and heir, who, after taking an active part in all his labours, has so successfully followed the example set by his uncle, that Minton's manufactory is now the largest in existence, and turns out the greatest variety of ware. With Minton and Copeland must be associated the names of Messrs. Brown-Westhead, of Caulden Place; and outside Staffordshire, the Coalport works and the Royal manufactory at Worcester. These are the principal producers of richly decorated china, for which the demand has greatly increased during the last few years. The greatest bulk of that ware is, however, made at Longton, one of the pottery towns which has a reputation for the cheapness of its goods; but of late a decided tendency to improve their quality and prices must be noticed among the generality of its manufacturers. Several of them, like Messrs. Ainsley, Moore, Barlow, and others, are trying to raise their goods to the same level as those of Stoke. There are about *thirty-five* firms in the Potteries making china, most

of them for the home trade, and over five times that number making earthenware. These two hundred and thirty manufactories are spread over an area of ten square miles, comprising the towns of Hanley, Burslem, Tunstall, Longton, Fenton, Shelton, and Stoke-upon-Trent, from which the electoral borough takes its name. These, which in a few years are likely to be amalgamated in a single town, form the district called the Potteries, containing already a population of 170,000 inhabitants engaged in the ceramic and iron trade. It has been remarked that since the foundation of Burslem, the mother town of the Potteries, the population of the district has doubled every twenty-five years, and it is easy to foresee the time when Stoke-upon-Trent will rank in importance with our largest commercial cities.

The export of porcelain is not large; but that of earthenware reaches one-and-a-half million of pounds. This does not appear large compared with the enormous amount exported by the iron or the cotton trades, but it is satisfactory if taken in combination with the quantity absorbed by the home trade, which represents quite as much. Our colonial trade with Australia, India, and British America is decidedly on the increase, and the same may be said as regards South America. On the contrary, our transactions with the continent of Europe have a tendency to decrease, and to fluctuate considerably with the United States, a very important market, which, in time of prosperity, might take as much as 800,000*l.* of granite ware.

To meet the competition of France and Germany,

on one side, and the Americans on the other, great changes have taken place in the management of our works. Several processes have been improved or simplified, and large manufactories have been built on better principles. These steps were not taken too soon; for if competition scarcely existed for our goods twenty years ago, that state of things has been much altered, and it will require a great deal of application and energy on our part if we intend to maintain our position as the largest and best producers of pottery in the world.

It is a fact, that America, which had not a single manufactory worth the name at the time of the New York Exhibition, produces now, with the assistance of British workmen, granite ware of tolerably good quality; and I have been told by an eye-witness that no less than seventy ovens are now at work at Trenton, in New Jersey. The clays and coals used by these potters are good, and if the salaries are higher than they are in England, they find a compensation in the heavy duties which, since the war of Secession, are levied on our wares.

Our commercial intercourse with France has not much altered, and the quantity of our goods sent across the Channel may be considered small compared with the importance of this market. The French are the largest producers of hard porcelain, and they make their common earthenware quite as cheap, if not cheaper, than ours. However, if they are strong at home, they have never affected our trade abroad, except

in the United States, where they send their porcelain in competition with English granite.

At the present time, the competition from which we have suffered most in Germany, the north of Europe, and as far as Italy, comes from a group of establishments situated in the Rhenish provinces and that neighbourhood: at Sarreguemines, Sarrelouis, Vaudrevange, Mettlach, Maastricht, and a few other places. Built in the centre of a populous district, where labour is still very cheap, their intelligent and wealthy proprietors share in each other's business, and consequently have no inducement for lowering their prices. They seem to have given a considerable portion of their time to the study of the various processes, and they have so far succeeded that they are a great deal more independent with regard to their men than we are. Possessing these advantages, we cannot wonder, if we have not been able to keep our hold on those markets which were the nearest to them. Besides, it is plain that the important rise which has taken place in the price of wages and fuel, and the consequent increase in the price of our wares, has acted as an encouragement to foreign production; and perhaps it may be good policy, in future, to resist any further opportunity which might offer to increase the price of our goods. It would, however, be singular if, in the course of time, England did not derive some benefit from this competition; she is used to close contest, and, everything considered, her position is an enviable one. Our home trade is excellent; and if the amount

of our exports does not progress so fast as we could desire, we know that we have in our commercial fleet more facilities than any other nation for sending our goods to those numerous countries where the trade of pottery is hardly established, and we rely on our honest and straightforward way of dealing for securing new customers for English manufacture.

GLASS AND SILICATES.

BY PROFESSOR FREDK. S. BARFF, M.A.

THE very brilliant and useful substance, which forms the subject of this article, is said to have been discovered by the Phœnicians. The story goes that some Phœnician merchants, while cooking their food on the sands near the seashore, noticed that the ashes of the plant, with which they made their fire, caused some of the sand to melt and form a vitreous substance; but whether this tale be true or not, it is well known that for a long time these people made glass from the materials which were abundant on their sea and river coasts.

Glass, however, was produced long before this by the Egyptians for the beads and ornaments used in adorning their mummies, and many specimens of these are in the British Museum. It is certain also that they well knew how to make certain substances impart colour to glass for the manufacture of most of these beads. The Romans made rich goblets of ruby glass, some of which are to be seen in collections in this country, as well as urns to receive the ashes of their dead, four of which, of a green colour, are also in the British Museum. The manufacture of these vessels proves that this nation was well skilled in the arts of blowing and modelling glass; and their designs, which we are now reproducing, show *that they were at least* not inferior in artistic skill to

those who have formed their taste in this highly civilized age. We have no record of glass being used for glazing purposes in ancient times. The Venerable Bede introduced it into this country about 674 A.D., and employed it in the adornment of church windows. Ordinary window glass was made at the works in Crutched Friars in 1557, and plate glass at the large works of the Ravenhead Plate Glass Company, near St. Helen's, in Lancashire. About 1776, flint-glass vessels were blown at the works in the Savoy House; and the second Duke of Buckingham brought over Venetian artists, at that time the most skilled, to work at glass making for mirrors, carriage windows, and other useful purposes. Their workshop was in Lambeth, and the date of their arrival in this country was 1673. The French were before us in the art of casting glass plates; and in 1688, Stewart commenced this branch of manufacture, which led to the establishment of the very famous works of St. Gobain. England has now large plate-glass works in different parts of the country, and these together yield as their weekly production at least 140,000 superficial feet of the best polished plate, or seven and a quarter millions of feet yearly. The value of plate glass made in England annually, including the rough kinds used for glazing roofs, &c., is estimated at 1,000,000*l*. France still stands very high, and her plates are extremely perfect in manufacture. St. Marie d'Oignies, in Belgium, also sends a considerable quantity of plate glass into the market. This branch of manufacture has not yet extended to America, which therefore is a large

customer of Europe. Formerly, glass making was very heavily taxed in this country, and in 1812 an additional duty was placed on the manufacture of the raw material, which so greatly depressed, it that the income which the State received fell from 328,000*l.* to 183,000*l.* per annum. Moreover, large quantities of foreign glass were imported, and this too hindered the development of the industry amongst us. On the repeal of the duty, however, the trade began to increase, and has now reached very large dimensions.

Glass appears to be a mixture of silicates, the nature and chemical composition of which will be explained in a later part of this article.

The materials used are principally sand, with an alkaline substance, either a salt of soda or potash and lime, though in some kinds of glass, oxide of lead takes the place of lime. Other materials are generally employed to correct impurities which may occur in the sand, and which, if present, always impart an objectionable colour to the glass.

There are two kinds of glass in ordinary use: common window glass, which may be divided into sheet, crown, and plate; and flint glass, which is used for decanters, wine-glasses, and tumblers; and, in some special forms, for ornamental stones in imitation of jewels, and also for lenses of telescopes and microscopes. The materials for making these different kinds vary somewhat, although the principal constituents are the same, viz. sand with some salt of soda or potash.

The scientific name for sand, or more properly for its

principal constituent, is silica. This compound silica, or oxide of silicon, also called silicic acid, possesses properties similar to those which belong to other acids, namely, it is able when brought into contact with bodies of an opposite character under suitable conditions, to unite with them and to form salts. Everybody knows that if tartaric acid be added to carbonate of soda, an effervescence takes place; carbonic acid passes off in the gaseous state, and the residue is composed of a portion of the tartaric acid, which unites with the soda, a double decomposition taking place. If silicic acid be mixed with carbonate of soda, and if the mixture be heated to a high temperature, that is, to a white heat, for some length of time, the same kind of action occurs: carbonic acid goes off, the silica or silicic acid uniting with the soda; and inasmuch as the soda salt was originally called *carbonate* of soda, after this action, in which carbonic acid is replaced by silicic acid, it is called *silicate* of soda. Silicic acid at the ordinary temperature of the air and in the dry state, has no action whatever upon carbonate of soda, but when heated sufficiently, the action becomes vigorous. A very interesting experiment may be performed in illustration of this fact in the following manner: if a mixture of carbonate of soda and carbonate of potash be heated in an ordinary fire-clay crucible, and if, when the mixture is melted, some perfectly dry sand be poured into it, effervescence will take place, owing to the expulsion of carbonic acid from the carbonate of soda and potash by means of the silicic acid. If this experiment be

performed in such a vessel that the carbonic acid can be collected, its presence is readily indicated by the usual tests. This experiment can be easily made by anyone who has ordinary chemical apparatus at his command. If the mixture of carbonate of potash and carbonate of soda be melted in a small platinum crucible; and if, when melted, it be removed quickly while very hot into a tall beaker-glass, and sand be then poured into it, the escaping carbonic acid will, on account of its being heavier than air, be retained in the glass, and its presence can be recognized by its turning lime-water milky (which is, in fact, a solution of lime in water), owing to the formation of carbonate of lime produced by the carbonic acid evolved uniting with the lime dissolved in the water. A mixture of carbonate of soda and carbonate of potash is here used, because either of these salts requires a very high temperature to melt it; but when the two are heated together, the fusibility of both is increased. When sand is heated with oxide of lead (common litharge) they unite, forming a compound similar to that produced by the silica uniting with the soda, as described in the last paragraph. In the first case, a *soda* glass is formed; in the second, a *lead* glass is the result. If these two glasses be mixed together and melted in a crucible, and if the proportions in which they are mixed be properly adjusted and the materials used be pure, a colourless and transparent glass will be formed, similar in appearance to that which is employed in the manufacture of decanters and tumblers. The same kind of glass may be produced by mixing all the materials in due

proportions and heating them together. If, instead of oxide of lead, lime be mixed with carbonate of soda and sand, and the mixture be heated to a high temperature, a glass will be formed in many respects similar to that of which oxide of lead is a constituent, but differing from it in several important particulars. First of all, the lead glass is highly lustrous, and has a great power of refracting light, so that when it is cut it presents a brilliant appearance, and by refraction readily produces the prismatic colours. This property does not belong to the glass containing lime, to anything like the same extent. Lead glass, too, is much heavier than lime glass, and is therefore unsuited to many of the purposes for which the latter is generally used, the principal of which is for the glazing of windows.

If, instead of oxide of lead, which is a chemical compound of lead and oxygen gas, or lime, which likewise is one of the metal calcium with oxygen, *carbonate* of lead or of lime be used, the silicic acid will expel the carbonic acid from these substances at a high temperature, just as it does the carbonic acid from the carbonate of soda and carbonate of potash. It is necessary, for a proper understanding of the scientific part of our subject, that this fact should be borne in mind, and that the acid properties of silica should be thoroughly recognized. Formerly, carbonate of soda was used in the manufacture of ordinary window glass, but now it is found more economical to employ *sulphate* of soda, which is a much earlier product in the manufacture of soda from common salt than is the carbonate, and is therefore less expensive. Carbonic acid is what chemists call a *weak* acid, by which is meant that its compounds are

not so firm and stable, as those which are formed by other acids with the same substances. Sulphuric acid is a strong and powerful acid, uniting very readily with the oxides of certain metals to form very stable compounds. But although this acid is chemically so powerful in its compounds, yet at a high temperature it is expelled by silicic acid, showing that this substance, so inert in its natural state and at the ordinary temperature of the air, becomes powerfully active in expelling other acids and in forming compounds when put under favourable conditions.

If a mixture of common sand and carbonate of soda, the carbonate of soda being in excess, be heated, a glass will be obtained which is slowly soluble in cold, readily soluble in hot water. To these compounds the name of silicate is given, so that we speak of the soda compound as silicate of soda, of the lead compound as silicate of lead, and the lime compound as silicate of lime. Silicate of soda and silicate of potash, when the alkali, that is to say, the soda or potash, is in excess, are both soluble. If a solution of one of these silicates be taken, and if carbonic acid be passed slowly through it, after a time a gelatinous, white, flocculent substance will be formed in the liquid, and eventually precipitated. This white flocculent substance is silicic acid combined with the elements of water, and is therefore called by chemists hydrate of silica. Now this hydrate of silica is soluble in water and in hydrochloric acid; and the method by which it can be brought into solution in water will be explained, when treating fully of *what are called* soluble silicates and their applications.

Soluble silicates are mentioned here, in order that a

more perfect understanding of the nature of silicious compounds may be obtained by those who do not possess a scientific knowledge of chemistry. The silicic acid in the silicate of soda is precipitated or separated out by carbonic acid, and here it appears, that an action, exactly the reverse of that which takes place at a high temperature, occurs when the silicic acid is removed from those conditions in which it has been seen to be (chemically) so active.

Suppose that to a solution of silicate of soda or of potash a soluble salt of calcium be added—the chloride, for example, which is a compound of the metal calcium with chlorine—a double decomposition will take place; the calcium will unite with oxygen in the silicate of soda, forming lime; and this will again unite with the silicic acid, forming silicate of lime; while the chlorine will unite with the sodium, forming chloride of sodium, or common salt.

Here then silicate of lime is obtained by a process very different from that which has already been described, namely, by the heating of lime with silica at a high temperature. The body formed in the latter case is chemically the same as that produced in the former, there being present the same weight of calcium, the same weight of oxygen, and the same weight of silicic acid in each. Again, if to a solution of silicate of soda, one containing a soluble lead salt, such as the nitrate, be added, the silicic acid will unite with the oxide of lead in the nitrate of lead, and the acid constituent of that body will unite with the oxide of sodium or soda, forming nitrate of soda. It is apparent, therefore, from

these remarks, that in whatever way the substances be made to unite, the effects produced as regards chemical composition are the same. If some of the silicate of lime or silicate of lead made by precipitation be dried and heated to a high temperature in a crucible, it will melt or fuse, and form a vitreous substance. In these last cases, as in many others which will have to be alluded to, the silicates formed are not soluble in water, although silicate of lime may be partially dissolved when heated in water under extreme pressure, by which the temperature is considerably increased, and even slightly in cold water.

To ensure the production of definite silicates by the agency of heat, the materials must be mixed together in proper combining proportions; for if more of the metallic oxide is introduced than can combine chemically with the sand, it will be melted in the mass, but the excess will not form a definite compound; whereas by precipitation the silicates formed always have, when thoroughly washed, a definite composition. This subject will be again referred to, when the manufacture of commercial glass is described.

It has been noticed that the glass found in the windows of old churches and in other places where it has been exposed to the prolonged action of the air and of moisture, has gradually become rough on its surface, and has lost to a considerable extent its transparency; this, which would be a defect in glass for the glazing of ordinary windows where transparency is desired, is rightly regarded as a beauty in glass which is to be used for the ornamentation of windows. Many reasons

have been offered in explanation of this apparently peculiar property of ancient glass; and that which appears to be correct is, that glass is a mechanical mixture of different silicates, some of which may be soluble in water, and others insoluble. The old window glass, whose manufacture will be more fully described by-and-bye, was made in a less perfect manner than modern appliances enable glass manufacturers now to produce the same article, so that the silicates composing the old glass were not as intimately mixed as those used in modern glass. By the slow action of air and moisture, portions of the soluble silicates have been dissolved out, and hence we frequently find a sort of honeycomb appearance on the surface of ancient glass, as well as a thin film, which, by refraction of light, causes an opalescence when viewed by reflected light. Efforts have of late been made to produce a similar effect by employing different methods in the process of manufacture, but without complete success. The fact, however, that such changes have taken place in this less perfectly fused glass, tends to show that if one silicate can be dissolved out, there cannot be *chemical* union between all the silicates. If a piece of modern window glass be heated in water under pressure in a closed vessel, it will present somewhat the appearance of ancient glass, for a considerable quantity of soluble silicate will be dissolved out from it. The object in dwelling on this matter here, is to induce makers to attend more to the chemical composition of their glass, for, doubtless, much more satisfactory results would be obtained both as to the quality of the material and the cost of its production,

if thoroughly scientific investigations were conducted by a competent chemist.

MANUFACTURE OF GLASS.

The first object in glass making is to obtain suitable materials. The sand which is employed for window glass differs from that which is required for flint glass, in that the latter should be as pure as possible. The maker can correct the impurities in the window-glass sand, provided they be not present in too great quantities; but it is far more difficult in the case of flint glass, to chemically counteract the influence of those substances which might impair its tint. So that the manufacturer would rather pay large prices for his sand, than trust to expedients which in their application might fail, and thus cause a greater loss.

One of the principal and most troublesome impurities met with in sand is iron in the form of oxide. There are two oxides of iron: one, the protoxide, which imparts a green colour to glass; and the other the peroxide, whose staining property is yellow. A very small quantity of the former will give an appreciably green tint, whereas it requires a large quantity of the peroxide to produce even a delicate yellow. In all glass making, it is found necessary to use something which will counteract the colouring properties of these two oxides. The material employed was black oxide of manganese. This is still used in certain glass-works, but from its injurious action on the fire-clay pots, arsenious acid or common white arsenic is employed to effect the same object. The chemical action

in the two cases is different: the black oxide of manganese is what is termed an oxidizing agent, and gives up, at a high temperature, a portion of its oxygen to the protoxide of iron, thereby converting it into the peroxide. It thus becomes comparatively harmless, by converting a quantity of that oxide, which gives a green colour, into the other oxide, which has little or no power of colouring except it be present in large quantities. The difficulty in using black oxide of manganese is the exact proportioning of it to the quantity of iron present in the sand, a quantity which cannot be easily determined. If the black oxide of manganese be used in excess, some of the oxide of manganese remains unreduced, and when this is the case, it gives a purple colour to glass. If used in exact proportions, it is reduced to an oxide which does not impart colour to glass. This may be seen in many of the old plate-glass windows which were employed for glazing purposes some sixty or seventy years ago, the colour of the panes being generally purple.

Arsenious acid also acts as an oxidizing agent, in that it gives up its oxygen to the protoxide of iron, converting it into the peroxide; but the arsenic itself, which has lost its oxygen, is reduced to the metallic state and is volatile, does not remain with the glass, but passes off by the flues of the furnace. If too much arsenic is used, it sometimes renders the glass milky or cloudy.

Before describing in detail the method of mixing and founding glass, it will be necessary to mention the *composition* of the vessels in which the glass is made.

They are called glass-pots, and differ in shape according to the different kinds of glass to be made in them. Glass-pots are made of fire-clay (generally the best Stourbridge), which is a silicate of alumina, and here great care is taken to select that which contains least lime or iron. It is ground, then moistened and well kneaded together, and left to ripen, while a certain quantity of old glass-pot is ground fine and mixed with the fresh fire-clay. Masses about the size of two hands are kneaded separately, the object being to exclude all air bubbles, and to obtain a perfectly homogeneous mass. The bottom of the glass-pot is then laid, the masses of fire-clay being pressed in with the greatest care, so as to avoid all cracks or places where air might enter during the slow process of drying.

The modern shape is round; though formerly certain glass-pots, called *cuvettes*, used in the purifying of plate glass, were square. Pots used in the manufacture of common crown and sheet window glass, generally speaking, are larger at the top than at the bottom; but whatever may be the shape of the pot, the method of its building is the same. The sides are carefully made of fire-clay, each piece being laid on by itself and kneaded like the bottom of the pot, so that it is slowly built up until it reaches the desired height. It is then dried very gradually, and the process is finished in artificially warmed chambers. Before putting it in its place in the glass-furnace, it is allowed to remain for some time in what is called a pot-arch, that is, an archway built of fire-clay bricks, along the side of which is a fireplace, by means of which the arch is brought up

to a red heat; and after it has been heated sufficiently, is removed while red hot and put into the furnace. Glass-pots are never allowed to cool, and with care they may last for several months. From this description of their manufacture, it will be clear that it is attended with considerable cost, varying from 5*l.* to 10*l.*

There are three different kinds of ordinary pots for crown, plate, and flint glass; and of these the last is decidedly the most expensive, as its top is covered over, and presents the appearance of a dome with an opening in front, through which the materials can be introduced when the pot is charged, and from which, when made, the glass may be drawn, in order to be blown into shape by the workman. In glass-furnaces the pots are sometimes arranged in a circle, with their mouths opening into the glass-house; but now a different construction is sometimes employed, since other methods of heating the furnaces have been introduced. It is hardly within the scope of this article to enter into a description of glass-furnaces; suffice it to state, that they should be of such a construction as to yield the greatest amount of well-regulated heat for the smallest consumption of fuel, and this object seems to be best effected by the adoption of Mr. Siemens' excellent principle of heating furnaces. For some years his process has been in use at the Thames Plate Glass Company's Works, where the saving of fuel has been very considerable, and the glass greatly improved, owing to the fact that impurities from the fuel employed cannot possibly find such easy entrance into the *glass-pot*. In any case, the construction of the furnace

is such as to be best adapted to the convenience of the workmen, according to the kinds of glass which they have to make. Differently arranged furnaces are used for bottles from those employed for crown and sheet glass.

Having considered briefly the manufacture of glass-pots, I shall proceed to the treatment of the materials to be employed. In making common window glass, ordinary sand, which does not contain any very large quantity of iron, may be used, the alkali employed being sulphate of soda, while the purifying material is either arsenic or black oxide of manganese. A small quantity of anthracite coal is added to the mixture, in order to assist in the reduction of the sulphate of soda, together with some lime. The materials are carefully mixed and placed in the furnace, where they are heated for some time, a process which is called "fritting." Its object is to perfectly dry the materials, so as to expel carbonic acid gas, which would otherwise cause swelling in the glass; but no combination must take place, to allow of silicates being formed, otherwise the alkali would melt first and attack the substance of the glass-pots, and part of it would be volatilized and lost. When this operation is completed, the fritt is put into the hot glass-pot, and submitted to the action of the heat of the furnace, until the glass is made, or "founded," as it is technically termed. In the case of sheet and crown glass this process lasts from sixteen to seventeen hours, for it will be remembered that the top of the pot is open to the furnace, so that the flames pass over the surface of its contents. In this

way the materials get heated more rapidly, than when a covered glass-pot is used.

M. Gehlen gives as a good mixture for window glass:

Sand	100 parts.
Dry sulphate of soda	50 "
Quicklime	20 "
Carbon, as charcoal	4 "

Different makers have different mixtures. This by M. Gehlen is given as *about* the proportions of the several constituents employed.

The charging of the pots is conducted in this manner: they are filled with lumps of fritt, and the heat of the furnace is raised as rapidly as possible, until in about eight or nine hours the fritt has run down or melted into glass. More fritt is then added, which also melts, and from time to time this is repeated, till the pot contains a sufficient quantity. After about sixteen hours the whole has become converted into glass, and the surface of the molten mass is covered with liquid salt and sulphate of soda. This scum is called glass-gall or sandiver, and is carefully removed with iron ladles. Some broken glass, or cullet, is now thrown into the glass-pot, a little at a time, the object being to cause any salt which may remain in the pot to rise to the surface, which is then removed, and so the glass is in this manner purified, after it has been further heated for some hours, to expel gases.

When the glass is made, and its temperature so reduced that it is in a doughy or pasty state, it is then worked off by the blowers into either sheets or tables, as is desired. The blowing of sheet and crown glass *is a work* of considerable difficulty and labour, and

one which cannot be successfully performed, except by a workman who has been brought up from boyhood in a glass-house. A quantity of the soft glass is collected or gathered on the end of a blowpipe, and the workman then blows into it, and distends it into a globular form. Now it is necessary, in making sheet glass, that that globular form should be elongated; the workman therefore holds his blowpipe, which is about 5 feet long, in a vertical direction, and the softened globe becomes pear-shaped. By dexterously swinging the blowpipe from side to side, which he does while standing on a plank placed over a sort of pit, and by causing it to rise on either side, he converts the pear-shape into a true cylinder, having rounded ends. When the cylinder has assumed the exact shape desired, he places his thumb on the end of the blowpipe, and holds the opposite end of the cylinder in the mouth of the furnace. The glass softens at the heated end, and the expanding air causes it to burst the opening. It is then shaped with a suitable tool, so that it is of the diameter of the cylinder. When the latter is cooled, a piece of hot glass is applied to its shoulder with a pontee, and is drawn out into a thread around it. This makes the glass hot. The thread of glass is removed, a cold instrument is applied rapidly, and the shoulder of the blowing is cut off. The glass is next detached from the blowpipe, and its ends removed, and it is then annealed for a short time, and cut down lengthways internally by a diamond. It is afterwards placed, with the long cut uppermost, in what is called a flattening kiln, that is, in a sort of oven or furnace heated to a

high temperature and having a perfectly smooth stone floor; after a short exposure the glass softens, and a workman, with suitable wooden tools, opens it out where it was cut by the diamond, and causes it to lie flat upon the stone. It is then rubbed by a wooden tool, and in this way is flattened, removed from the flattening stone kiln, and placed in a hot chamber, in which it is allowed to cool slowly, for the purpose of "annealing."

Sheet glass, formerly called broad glass, was originally made on the Continent; but its manufacture, first established in this country by the introduction of foreign workmen, has extended to very large dimensions, and the quality of English sheet is now quite equal, if not superior, to anything that is produced abroad. The advantage which it possesses over crown glass is, that much larger sheets can be made, and this is very easily noticed if we examine the larger dimensions of common window panes compared with those which were formerly made. Even now the workmen employed in this class of manufacture are generally Belgians. A sheet-glass blower must be very strong, and have great skill in handling his blowpipe, for the cylinders which he blows are frequently sixty inches long, and their weight is very considerable. Glass shades are blown by sheet blowers. These sometimes are very large, and require great skill. When their shape is to be that of a cylinder with a dome top, they are made as in the ordinary course of blowing a cylinder of sheet glass, but instead of one end being burst as described, they are simply detached from the blowpipe. When

they have to be oval or square at their bases, they are blown into wooden moulds of the required form, which have their insides charred. The gathered mass of glass is placed inside such a mould, and is then blown into until it touches the sides. This is an operation requiring great strength and delicacy; strength to blow with sufficient force to bring the softened glass to touch the mould in all its parts, and delicacy to prevent the pressure from being so great as to cause the outside of the glass shade to receive marks on its surface from the mould.

The shaping of the molten glass into tables of *crown* is different in detail. The globular mass formed by the first blowings is held by a workman vertically over his head. An assistant gathers a small quantity of soft glass from the furnace on the end of a pointed iron rod, and causes it to adhere to the flattened surface, at a point opposite to that to which the blowpipe is attached. The glass near the blowpipe, while hot, is touched with a cold instrument, and immediately cracks around its neck, detaching the blowpipe from the mass. The pointel is taken by the blower, and the opening formed by the removal of the blowpipe is placed opposite to what is called a "flashing" furnace, that is, a furnace with a large circular opening in its front, and which is heated to such an intense degree that it is impossible for a person unaccustomed to it to approach within several feet of the furnace-mouth. The workman generally wears a shield or screen to protect the upper part of his body and face. The glass becomes softened by the heat, and the workman gives his pointel a rotary

motion, somewhat similar to that which a housemaid gives to a mop when she trundles it; and as the glass softens, the opening gets larger and larger, until at last the softened mass instantaneously flashes out into a circular sheet, an operation which produces a very startling effect upon the eyes of anyone beholding it for the first time. The circular crown table thus made is detached from the pointel, and the mass of glass which caused it to adhere forms what is known by the name of the bull's eye. The table thus made is, like the sheet, placed in an annealing furnace, and left there for a proper length of time.

The manufacture of *plate* glass is altogether different from that of crown and sheet. First of all, much greater care is taken in the selection of the materials, the sand used being of a purer kind than that employed in the manufacture of common window glass; the alkali is of a better quality; and more caution is taken in all the manipulative processes prior to the melting of the mixture. Arsenious acid is more frequently used than manganese for the correction of the iron impurity. It has been noticed that in the plate glass-pots there are grooves placed around their sides, and these are intended to receive metal claspers, by means of which the pot can be removed bodily from the furnace. In former times the glass was made in large pots, and then ladled out into smaller ones, of a square form, called cuvettes, and in these it was left exposed to the heat of the furnace for a length of time, in order that it might be refined, by the rising of impurities to the surface and by the escape of air bubbles. The

use of these cuvettes is now discontinued, and the pot in which the glass is founded is removed from the furnace and its contents poured upon the tables on which the plate is formed, by the action of rollers. A plate-glass table is made of iron; its surface is smooth and of the size required to make a large plate, and it is placed upon wheels and run upon a tramway from one part of the glass-house to another, so as to be opposite to the mouth of the furnace from which the glass-pot has to be removed. Along the sides of this table, taken lengthways, movable strips of iron are placed, rising above it to a sufficient height to secure the desired thickness for the glass plate, and on these strips runs a roller, so adapted that it can be made to pass pretty readily from one end of the table to the other. The contents of the glass-pot, when placed over the table by means of a crane and tilted up, fall out somewhat as a lump of dough would fall from a kneading trough if it were inverted, for it must be borne in mind that the glass in this process is not in a very *fluid* state. The roller is made to pass rapidly over the softened glass, and in this way spreads it over the table until it comes in contact with the strips placed along the edge, which serve as gauges for determining the thickness of the plate. After the plate is formed it immediately sets, and is removed while hot into an annealing furnace, which is always so placed, that the glass can be transferred to it from the table with the least possible delay. In this furnace several plates of fresh-made glass are deposited, and *are allowed to cool* extremely slowly, in order that

the glass may be properly annealed. When this process is completed, the plates are removed, the edges are trimmed off with a diamond, and one plate, bedded in plaster of Paris, is placed upon a flat stone receptacle; another plate, also coated on one of its sides with plaster of Paris, is made to adhere to a piece of machinery placed directly above the other plate, and is so situated with respect to this latter, that the two surfaces are perfectly parallel one to the other.

It should here be mentioned, that the side of the plate which touches the table is always rough, and has no polish, while that over which the roller is passed is slightly undulating, and has a bright polish similar to that of a sheet of blown glass, and which is technically known as "fire" polish. The machine to which the upper plate is attached is so arranged, that when set in motion it causes it to move in just the same direction that a plate would do if moved by the human arm; this is therefore called an elbow motion. Boys stand by the sides of the two plates, and throw fine sand and water on the lower one, so that the opposed surfaces mutually grind one another, and when this process is completed on one side, they are reversed and the same operation is performed on the other side. The plates have now the appearance of ground glass, and the surfaces are further ground by fine emery powder, which causes them to be much smoother and more ready for the final polishing. Formerly this was entirely done by hand, women generally being the operators, and oxide of iron, called crocus, mixed with water, the material employed for polishing.

Now, however, a more rapid and perfect method is adopted by the use of machinery. A table is prepared which moves from side to side, giving to the plate a lateral motion; and above is a beam, in which holes are drilled at intervals, through which short iron rods, nearly an inch in diameter, pass. On these are padded iron buffers, covered on their under surface with leather; while, pressing down these rods, and therefore the buffers, are springs, which act with considerable force, but which are able to yield to pressure caused by any inequality over which the buffers may pass. The glass plate is fixed upon this table, and its upper surface is exposed to the action of the buffers, while oxide of iron, in a very fine state of division and mixed with water, is allowed to come upon its surface. The glass travelling from side to side is rubbed by the buffers in a lateral direction, and has also a longitudinal motion, so that every portion of it is rubbed equally. If any inequalities occur on the glass, the springs which press down the buffers give way and allow them to rise over it, and this process is continued for some time, until at last the plate receives the polish so characteristic of plate glass. It is then removed from the table and examined by skilled persons, and whatever defects can be removed by hand, are remedied.

Another kind of plate glass, called "patent rolled plate," is made by ladling out from a pot molten glass in the proper state of consistence. The ladle is brought over a small glass-table, and a similar operation is performed to that already described. This

patent rolled plate is sometimes made with grooves on one of its surfaces, or with patterns in imitation of diamond quarry glazing, and, in fact, with any designs, according to the taste of the manufacturer. These designs are all engraved upon the table, and communicate their patterns to the soft glass; but the smooth surface of such glass which comes in contact with the roller is slightly undulating, though polished. This method of glass-making was invented and patented by Mr. Hartley, the noted manufacturer, of Sunderland.

A lighter kind of plate glass, which is principally used for glazing the better class of pictures and engravings, and called "patent" plate, is simply sheet glass polished after the manner of plate glass. Crown glass, which only admits of being cut into small squares, is also used for picture glazing, but is more carefully prepared, and is called by the name of "flatted crown."

Looking Glasses.—Plate glass is employed for making looking glasses, and two processes are now in use for silvering them, the first of which consists in applying a sheet of tinfoil saturated with quicksilver to one side of the glass. The operation is conducted as follows: on a perfectly smooth table a sheetof stout tinfoil is laid, and on it is poured quicksilver, which is distributed evenly over the surface with a hare's foot. When the whole sheet is amalgamated with the quicksilver, more of that substance is poured upon it, until it flows freely over it. The glass plate to be silvered, having been made *perfectly* clean, is floated upon the surface of the quicksilver, an operation requiring care, and is then covered

all over with weights, by which means the excess of quicksilver is pressed out, and the glass comes in contact with the amalgamated sheet of tinfoil, to which it adheres perfectly. This ancient method of silvering glass has some advantages over the one next to be described. The colour of the plate is, according to artistic taste, better, and with care the plate will not lose its brilliancy for years. I have in my possession some old glasses, the silvering of which is very beautiful, except where it has suffered from mechanical injuries. Silver can be precipitated from a solution of nitrate of silver in several ways, and in some of these specimens was like a bright film. If a crystal of nitrate of silver be put into a test-tube with some bitartrate of lime, and the mixture be rendered ammoniacal and gently warmed (it being kept in motion during the experiment), its sides will be covered with a very brilliant deposit of metallic silver. Oil of cloves and grape sugar have also the power of reducing metallic silver from ammoniacal solutions of the nitrate, when gently warmed; but the mixtures must not be made too hot. In silvering plates of glass, they are first well cleaned, then placed in a perfectly level position, and the silvering liquid is poured over the surface, the room in which the operation is performed being kept sufficiently warm to assist the deposition. When enough silver has been deposited on the glass, the liquid is poured off and the plate dried, while the silver film is protected by being coated with a suitable hard varnish. The composition of the mixtures used by different persons is generally kept secret, though

the chemical principle of the reduction of the silver salt is the same. Glasses silvered by this process sometimes lose their brilliancy, by becoming covered on their silvered side with small spots. It is however stated that this results either from a bad system of deposition, or from the film of silver not being sufficiently thick and solid.

Flint Glass, although called by this name, is not made from flint, but from the best sand, of pure and dazzling whiteness, obtained from Alum Bay, in the Isle of Wight, and from Fontainebleau, in France. The cost per ton is from 1*l*. to 1*l*. 15*s*., whereas the price of the sand employed in making plate glass is about one-eighth of that amount. The alkali employed is generally extremely good carbonate of potash, whereas soda is used in the manufacture of the other kinds of glass which have been described. The addition of a small quantity of black oxide of manganese is sometimes necessary to correct the slight tint imparted by iron, which seems to be always present in minute quantities, even in the purest samples of sand. Oxide of lead in the form of red lead, in this sort of glass, takes the place of lime. The advantages derived from using the oxide are, that it makes the mixture more fusible, and also imparts that particular brilliancy and lustre so peculiarly characteristic of well-made flint glass. In different works various mixtures are made for the composition of the glass; but to give an idea of the proportions in which the materials are mixed, it will be well to quote the statement of *M. Payen*, who says that of the finest crystal flint

glass, the following is the composition: sand, 3; red lead, 2 to $2\frac{1}{4}$; carbonate of potash, $1\frac{1}{2}$ to $1\frac{2}{3}$. A little nitre or saltpetre is used as an oxidizing agent. The glass-pots employed in this branch of the manufacture are covered, so that the flames of the furnace do not come in contact with the materials, the object in thus isolating them from direct contact with the flame being to prevent the entrance of impurities, by which the colour might be injured. On account of the pots being covered, the materials take a much longer time to get hot, and require quite double the time in founding than sheet or plate glass; the presence of oxide of lead materially assisting the rapidity of the fusion. When flint glass is ready for working, the time required to work off a pot of it is much longer than that which is required for a pot of crown or sheet; and it is a matter of considerable importance, that the furnace-man should so manage his fires, as to keep the glass in a proper working condition, that is, he should not let it get too cold (therefore too solid) nor too fluid. Flint glass is worked off by the blower into wine-glasses, tumblers, decanters, and other suitable vessels. Let us take a wine-glass as an illustration of the method of working. A small quantity of glass is gathered on the blowpipe, which is much smaller than that used in making sheet, and is blown into a bulb, which may be slightly elongated or globular, the forms being given to it by the motion which the workman imparts to his blowpipe while he is blowing, or after he has blown, into the mass. In the case of a wine-glass, an assistant boy gathers a small quantity

of glass on the end of a small pointel, or solid iron rod. This is placed on the side of the globe opposite that which is in connection with the blowpipe, which is then detached by touching the glass nearest it with a piece of iron, wetted with cold water: this causes a crack, and a gentle tap causes separation. The workman then moulds the opening made by detaching the blowpipe, in order to do which, he has to apply the glass often to the mouth of the furnace, to soften it. He then opens out the globe into the shape of a cup with a pair of small iron tongs, with legs uniform in shape, slightly tapering and smooth, and he uses a peculiar kind of scissors for trimming the edges. The other parts of the glass are moulded with the tongs, accuracy of size being obtained by means of measuring compasses and a scale. The workman sits during this operation in a seat with arms, laying the pontee on them, and turning it, so as to make it move backwards and forwards with his left hand, while with the tongs in his right he gives the glass the desired form.

Before passing on to a description of the manufacture and composition of coloured glasses, it is necessary that I should make a few remarks on the difficulties under which our English glass-makers labour, owing to not paying sufficient attention to the scientific treatment of their mixtures. It has already been stated that glass is composed of a mixture of silicates, which are definite chemical compounds. Some are much more dense than others, and are therefore liable to sink, so that the glass taken from one part of the

pot will be very different in composition from that taken from another part; besides this, it is found, on examination, that other portions of the materials employed are present in such proportions, that they cannot possibly exist in the form of true silicates. M. Dumas, the distinguished French chemist, asserts, and with truth, that glass ought to be a true chemical compound. This, however, does not seem to be the opinion here; and sufficient attention is not paid by English manufacturers to mixing their materials, so as to form definite silicates, the result being that glass is produced with a striated effect. This is easy to be seen in the common kinds, as in bottle glass; but owing to the more careful and prolonged fusion of the finer varieties, such as plate glass, this defect is to a considerable extent remedied, though not altogether overcome. In the French manufacture of plate glass, more attention has been paid to the chemical composition of the various silicates which enter into it. At St. Gobin, a plate glass is produced which, on analysis, is found to contain definite silicates, and without any excess of material which does not enter into chemical combination; and the consequence is, that this glass is more perfect and homogeneous than that made in this country. No doubt this superior quality is owing to the fact, that the famous chemist, Gay-Lussac, devoted much of his time to assisting in the manufacture carried on at these works. We cannot overestimate the importance of a scientific superintendence, not only of glass-works, but of all other manufactures in which chemical reactions take place; for although

experience may lead a cautious observer to produce substances of nearly correct composition, yet the assistance of a scientific observer is of the greatest importance, because, what under other circumstances must be simply empirical, is under his guidance carried on according to definite and fixed laws.

Mention has already been made of how, in the case of mixing carbonates of soda and potash, the one assists the fusibility of the other, and this is more particularly true in the mixture of silicates in the composition of the ordinary glass. Silicates of soda and potash are separately much more infusible than a mixture of the two, and the addition of other silicates to them renders them more fusible still; silicate of lead, as has already been mentioned, causing the glass into whose composition it enters, to fuse at a much lower temperature than it would do if that silicate were absent. Again, if the silicate of lead be present in too large proportions, and if great care be not taken in the manufacture of lead glass, the silicate of lead, from its greater density, will sink lower among the molten silicates, and will therefore cause a larger proportion of lead to be in the glass at the bottom of the pot than there is at the top. We often notice in tumblers and decanters of the cheaper kind, that there are very distinct striæ running through the whole substance in some particular portion of the glass. Now this is owing to the greater density of the lead silicate, which sinks lower down in the collected mass of glass, and therefore imparts to it this peculiar effect. When a pot of flint glass is worked off, that which remains at the bottom usually contains

more lead than that which is worked off in the earlier part of the day.

Coloured Glasses.—It has been before shown that silica unites with metallic oxides; in fact, glass is nothing but a compound brought about by the union. With certain metallic oxides, silica forms coloured silicates or glasses; and these, when fused with colourless glasses, impart to them the colour of the silicate. Oxide of iron colours glass either green or yellow, according to the nature of the oxide; the silicate of the protoxide of iron being green, and that of the peroxide, yellow of a slightly brownish tint. Copper forms two oxides, the suboxide and the protoxide; the suboxide colours glass red, while the protoxide renders it green. Black oxide of manganese colours glass purple; but if large quantities be used, it makes it perfectly black. Sesquioxide of chromium imparts a beautiful green colour to glass, while oxide of uranium produces an opalescent effect of yellow with a tinge of green. This latter, by the way, has the power of reducing the ultra-violet rays of the spectrum to luminous rays, and when held in the rays of a spectrum obtained by the electric light, produces an extremely beautiful effect, which is called fluorescence. A small quantity of the oxide of gold tints glass pink, but the colour becomes extremely rich and ruby-like when a larger quantity of the oxide is employed. Oxide of cobalt in very small quantities yields, with silicic acid, an intensely blue silicate. This substance, carefully prepared in a special manner and ground to a fine powder, forms the well-known water-colour pigment called smalt. Oxide of

silver stains glass from a delicate lemon tint to a deep orange, in proportion to the quantity of the oxide employed.

With the exception of the last-named colouring material, the above mentioned are mixed together with the substances which form the glass, and are melted in the usual way in glass-pots, except that they are treated with considerably more care, in order that their tints may be true. Oxide of silver, however, is never mixed with the materials of which the glass is made, but is applied to the surface in the following manner: a solution of nitrate of silver mixed with some substance, such, for instance, as chalk, may be painted upon the parts of the glass which it is desired to stain, and these are heated to a dull red heat, in what is called a "muffle." Wherever the oxide of silver comes in contact with the glass, the latter is stained more or less intensely, according to the quantity of silver present. Pure metallic silver may be melted with metallic antimony, and the mass ground to a fine powder in water. This powder, after being mixed with some Venetian red and gum water, is applied to the surface of the glass, which is, when dry, heated to a dull red heat in a muffle, producing the yellow stain, which can be seen after the Venetian red and the excess of silver have been scraped off. The reason why silver, or oxide of silver, is not mixed with the glass materials and fused with them, is because it does not readily unite with oxygen, and when it has done so, it loses its oxygen again at a high temperature, and becomes *reduced to* the metallic state; and inasmuch as metals

have no effect whatever in staining, silicate glass made in this way would not have the yellow colour which it has, when the silver is heated upon its surface to a much lower temperature in a muffle; for the temperature to which the constituents of the glass must be heated, so as to cause them to burn it, would be so high, that the oxide of silver first formed at a lower temperature would be reduced to the reguline or metallic state. Gold also, like silver, does not unite with oxygen readily, or remain in union with it at high temperature; therefore great care is required in the preparation of glass to be coloured by oxide of gold; the form in which it is used being generally that of the purple of Cassius, made by precipitating a salt of tin with a salt of gold. This substance is mixed with the glass to be coloured, and heated in a suitable glass-pot. Portions of it are gathered and allowed to cool, these being generally of a yellowish, brownish, and sometimes reddish tint, though they have not in any case the same beautiful red colour which they produce when applied, as will be immediately described, to the surface of white glass. A certain quantity of white glass is gathered from the glass-pot in the soft state with one of these pieces of gold glass; the whole mass is heated until both become soft, and is then blown and formed into a sheet, which, on examination, will be found to consist mainly of white glass, with its surface thinly covered with the glass stained with oxide of gold, while the beautiful ruby colour, which the gold imparts to the glass, appears pure and distinct. If such glass as this be heated to too high a temperature, as when

it is used in the manufacture of stained glass windows, the ruby colour is in part, and sometimes altogether, destroyed, for the oxide of gold loses its oxygen, and metallic gold is left behind, which does not yield a colour to the silicate. I have in my possession a piece of French glass of a pale sapphire tint, which, when heated in the oxidizing flame of the blowpipe, assumes a brilliant and intense ruby colour, showing that in the first condition the gold is not in a state of oxidation sufficient to impart colour to the glass.

When the suboxide of copper is mixed and fused with the glass which it is intended to colour, the result is an opaque substance, almost like red bottle-sealing-wax, which is treated in a manner exactly similar to the gold glass; viz. it is coated with white glass, and blown and shaped into sheets, which owe their intense ruby colour to a thin film of the coloured glass closely adhering to the mass of the white upon which it is placed. Glass made in this way is called "coated," and sometimes "flashed" glass, and is extremely useful for ornamental purposes, for by the action upon the coloured surface of hydrofluoric acid, the ruby coating can be eaten away, and the white glass beneath left entire. If the backgrounds of the patterns be painted upon the ruby side with a material like Brunswick black, which is able to resist the action of hydrofluoric acid, and if the plate of glass, on its ruby side, be exposed to the action of the vapour of this acid, or to the action of the acid in solution in water, in a short space of time the pattern will be eaten away; and if the Brunswick black coating be removed with turpentine,

a sheet of ruby glass will be obtained with a white pattern etched upon it.

Owing to the powerful colouring properties which oxide of cobalt exerts, a very deep-coloured blue glass can be made, which can be treated like the red copper glass, and may be made to coat and cover in the same way the surface of plates of white glass. Purple glass, coloured with oxide of manganese, and green glass are also sometimes used as coating materials for white glass, but other colours are never employed in this way.

It is manifest that if different metallic oxides be used with the same glass, mixed tints will be produced, so that by mingling small quantities of oxide of cobalt and protoxide of copper, a blue glass having a greenish hue may be obtained. The revival of glass painting has caused manufacturers to turn their attention to these mixtures, in order to produce tints resembling those of ancient stained glass. Messrs. Powell and Son, of Whitefriars, were the first to perform experiments on these mixtures, and after much laborious attention and patience their efforts have been crowned with great success, for they have been enabled to produce glass as beautiful in tint and in texture as the best specimens of ancient manufacture. Their example has been followed by others, such as Messrs. Hartley of Sunderland, and Messrs. Chance and Co. of Birmingham.

While treating of the effect produced by different metallic oxides upon colour, it may be well to mention that the opaque glasses used for such purposes,

as the enamelling of watch-faces, are made by mixing with the materials a certain quantity of arsenious acid (or white arsenic), in much larger quantities than when it is employed simply to correct the tint imparted to glass by the iron impurities in the sand. Oxide of tin also renders glass white and opaque, and a certain quantity of bone ash will produce a similar effect, though not in so satisfactory a manner.

Glass Painting first became general in this country at the time when the Early English style of architecture prevailed, and some of the best specimens were executed during that period. By the best specimens is not meant, that the figures painted upon those windows were artistically as correct as similar works of a later date, but that they were designed and executed in accordance with those principles, which should always govern the adaptation of a substance like glass to ornamental purposes. The earlier mediæval artists depended for effect more upon the boldness of their outline, than upon the intensity of their shading or the delicacy of their manipulation. The form of a thirteenth-century figure is merely indicated by a few bold and well-drawn outlines, the features being formed by lines, the pupils of the eyes by simple well-shaped masses of opaque pigment; and such a treatment as this was quite sufficient to convey what was, to the observer, more or less a symbolical than a truthful representation of the Scripture history which they were intended to illustrate. These artists remembered that windows are openings in a building, through which

light has to pass, and they did not therefore, like many of the later imitators, render them opaque by masses of intense shadow, which perfectly obscure the colour of the glass upon which the picture is painted, and render the passage of light through it simply impossible. The thirteenth-century glass painters, too, in the treatment of their shadows, bore this great principle in mind, and instead of daubing and stippling them on, usually indicated them with a thin wash of enamel colour, intensified in parts by lines crossing one another, and therefore called cross-hatching, through the interstices of which the light, although subdued, was able, in a measure, to pass.

But as the object of this article is not to discuss the merits of the various styles of glass painting, however much I might desire to enlarge upon it, I pass on to a description of the methods employed in the manufacture of stained glass windows. In the first place, after a design has been drawn, in which the effect of the window as a whole can be carefully considered, cartoons of the figures and ornament are made of the exact size of the intended painting. And here it should be noted that all the lines should be extremely clear, precise, and well drawn, because it is from these that the workman, who is not usually himself an artist, has to convey on the glass the feeling of the artist. The cartoon, when completed, is laid down in pieces for convenience sake on a table, and fastened with small nails. The glass-cutter then selects the various coloured glasses which are required to be inserted in their proper places, so as to carry

out the design of the artist. For instance, a piece of white or yellow-tinted glass is cut to the shape of the face. If the figure be a small one, the hair also is included in this; and probably in the figure of a saint, the nimbus which surrounds the head may be included; while in larger figures, particularly in the earliest styles, the face was of glass of one tint, the hair of another, and the nimbus of one or more tints, different from either of these. Sometimes, in the later styles, the hair, after the face was painted and burnt in, was stained with the silver stain already described, so that when the glass was cleaned, it was of a yellow colour. However, not to enlarge more upon these points, which really belong more to the artistic than to the industrial part of window painting, let us proceed to the consideration of manipulative details. The outlines of the figures and ornament are painted with a substance called "tracing brown," made by mixing with a flux some oxide of iron, heating them together in a crucible, and grinding the product to a fine powder, which is mixed with certain vehicles adapted to the particular use to which it is to be applied. Different fluxes are employed by different glass painters; some contain borax, because such fluxes fuse more easily, and therefore cause the glass which is painted to be exposed for a less time and to a lower temperature, than when less fusible fluxes are used. They are, however, attended with this inconvenience, that the boracic acid contained in them is gradually acted upon by moisture and becomes hydrated, and in this condition often causes the painting to peel away.

Harder fluxes, although they have the disadvantage of causing the glass to be submitted to a much higher temperature for a longer time in the kiln or muffle, are the best, and with judicious management can be used without any injurious consequences to the work on which they are employed. Lead fluxes, containing oxide of lead, are sufficiently fusible for all ordinary purposes, and are not liable to the same objection as fluxes containing borax. Suppose it is desired to paint the outlines of a face, the glass is cut to the shape of the face in the cartoon; it is then laid upon the cartoon, and the painter, seeing the lines through the glass, is able to trace them with his brown paint upon its surfaces. He generally uses gum water as his vehicle, and puts on the shading also with the same mixture, though sometimes it is found necessary to use a substance which is not affected by moisture, as, for instance, tar-oil. It is impossible, in the short space of this article, to indicate those occasions on which one should be used in place of the other; a knowledge of this can only be obtained by consulting authorities in which details are more minutely given, or by watching the operations of the glass painter in his workshop. When the face is finished, it is removed, and another portion of the figure, say a piece of the drapery, is proceeded with in exactly the same way; and so, by a repetition of this process in all parts of the figure, it is completed, and looks very much like a puzzle, the parts being put together on the cartoon before the work is finished, in order to see that the whole is harmo-

niously treated. In shading the faces, hands, and those parts of the drapery which require it, a glass easel is used, on which the figure is put together, and the parts made to adhere by wax, so that the artist is able, while painting, to form an idea by transmitted light of the effect which will be produced when the window is finished. The ornament is painted in a similar manner, but usually not with the same care in the details of its execution.

When all the glass is painted, it is fired in a muffle, upon the proper construction of which a great deal depends. It is usually made of iron, and should not be more than 15 inches from its bottom to the top, though its width may vary. It is never well to have muffles for firing glass for painted windows larger than about 2 feet wide by 2 feet 6 inches deep. The top of the muffle is usually slightly arched from side to side, and it is placed in the furnace on a tolerably thick stone floor, so that the bottom may not get too hot. The fire, which is lighted below, is allowed to play up its sides and over its top, the flue being so placed as to draw the flames in that direction, for a top heat is the best heat for firing glass regularly. The muffle is arranged with ridges in its sides, passing from front to back parallel to one another on one side, and exactly opposite to corresponding ridges parallel to one another on the opposite side. These metal ridges are intended to receive iron plates, and there is generally about an inch or rather less between the top of one plate and the bottom of another when the muffle is perfectly filled. The plates are covered

over with perfectly dry powdered chalk or whiting, and the pieces of glass are laid upon them with their painted sides uppermost. When the plates are charged, they are put into a muffle with an iron door, in the centre of which is a hole, and a conical tube with the base attached round it. It is larger than the opening at the other end, which projects some 6 or 7 inches from the surface of the muffle-door at right angles to it. A second door is then placed at a short distance from the first, the tube passing through a hole made for the purpose in it. The orifice is usually stopped by a piece of fire-clay, which can be removed at pleasure. The use of the tube is to enable the manager of the kiln to look into the muffle, from time to time, to see that the glass does not get too much heated. When the firing is completed, the fire is raked out and the muffle is allowed to cool very slowly, and by this process the glass becomes annealed.

When it is desired to apply to any portion of white glass some yellow silver stain, this can be done either in the first firing by floating it on to the places to be stained, and allowing it to run in a sort of stream from the brush, so that it will evenly cover the surface and cause the heavier portions of the stain, namely, the mixed metallic silver and antimony, to sink regularly to the bottom, and come fairly in contact with the glass. If the staining is to be performed in the same firing as that by which the painting is to be fixed, it is quite clear that the outlines of the part to be stained must be painted in, in tar-oil, or in some such substance which is not affected by the moisture of the stain.

However, in general, the staining operation is performed after the first firing, that is to say, those pieces of glass to which the silver stain is to be applied are stained in the method above described after the first firing, and are then fired again, because the heat required to produce a good stain from silver is of a somewhat different character from that which is required simply to fuse the flux that binds the pigment to the glass. A longer and less intense heat, technically called a "soaking" heat, is the best for producing an even and pure yellow tint. If the temperature be allowed to rise too high, the oxide of silver, which alone can stain the glass, gets reduced wholly or in part, and when this happens to only a slight extent, it destroys the transparency of the stain; and when it happens to a great extent, it destroys its colour altogether, making the glass opaque.

It is a matter of astonishment to me that glass painters do not use a ruby stain, which, with a little practice, can be managed quite as successfully as the yellow silver one. It is true that it would be impossible to fire the ruby and the silver stains together, and it would not be at all convenient to fire the ruby stain at the first firing of the painted glass. The method of staining ruby is as follows: grind up carefully some black oxide of copper, mix it with water (or with a small quantity of gum added), float it on the parts to be stained, place it in a kiln and heat it. Black oxide of copper, when mixed with glass and melted in a glass-pot, makes the glass green; suboxide of copper, which contains less oxygen than the black oxide, when treated

in the same way, makes it red. Now, if it can be reduced to the lower oxide of copper, while the black oxide of copper on the surface of the glass is heated, it will then colour the glass red. The best way of reducing the black oxide is to connect the muffle with a gas-supply pipe, and allow coal gas to pass during the whole time that the heating process goes on. The action of the gas, which contains hydrogen and carbon, is to take away oxygen from the black oxide of copper when it is at a high temperature; and as soon as sufficient is taken away by the hydrogen to reduce the black oxide to the state of suboxide, it stains the glass red. It does not matter if the reducing action be continued longer, so that the oxide of copper be reduced to the metallic state; for at that temperature the stain produced by the red oxide of copper is not removed by the continued action of hydrogen gas. The employment of this process would certainly enable artists who paint in the later styles of glass painting, to very much enrich their draperies, and to produce, more easily, effects which now can only be obtained by a complicated system of lead work.

When the pieces of glass which have been fired are perfectly cold, the next process is to unite them altogether by peculiarly shaped strips of lead, which are of various kinds, according to the character of the subject required. The lead has a thick part or core, and at right angles to the top and bottom of this are thin plates called the "leaves." The core is milled with little ridges running at right angles to them, so as to enable the workman to bend the

lead about with facility. The edges of the piece of glass to be leaded are placed between the leaves and resting upon the core, and the lead is thus arranged all round the glass, and is then laid in its proper situation upon another cartoon, prepared from the one from which the figure was painted, and indicating simply, by lines, where the lead work is to come. The first piece is fixed by means of nails temporarily placed through the lead. Those pieces which touch it in the design are put in their proper positions, so that the edge touching the next piece will be underneath the opposite leaves to those which confine the first. This operation is repeated till all the parts of the design are surrounded by lead, and by it united to one another; the joints being secured by solder, generally applied by gas. Nothing now remains but to fill in the interstices between the lead and the glass, so as to make the window firm, solid, and water-tight; and this is done by rubbing into them with a scrubbing brush a cement usually made of white lead, oil, and plaster of Paris. This composition varies in different stained-glass works, nor is it material, provided that the substance hardens, does not crack, and is waterproof.

From this description it will be seen that the various colours in the different parts of the window are put in as pieces, and that no colours, properly so called, are applied by the brush to the surface. There are, however, certain tints of the "tracing brown," which can be obtained by the addition of black oxide of manganese, or by a different method of preparation of the oxide of iron, to give it its body. Sulphate of iron,

when heated, loses its sulphuric acid, and the oxide, which was, as sulphate, in the state of protoxide, becomes, by heating, the red or peroxide of iron; its tint when made in this way being generally lighter than the tint of that form of oxide which is employed as ordinary tracing brown. It is sometimes called flesh tint, though this is decidedly an objectionable name for it.

The use of enamels—that is, substances which impart various colours to the glass when placed on its surface by their fusion—is not admissible in windows which pretend to belong to any of the earlier styles of glass painting; though enamel painting is used for the decoration of houses, and sometimes, as I consider very improperly, for the decoration of church windows. One sheet of glass, colourless and transparent, or it may have its surface ground, is usually employed. A subject is painted on it with enamel colours, much as subjects are painted upon porcelain. When the work is completed, the glass plate is fired, and thus the colours become semi-transparent, and perfectly adherent to the plate; but they are not clear and bright, and transparent, as are the colours of glass which is coloured in the pot, and therefore have not the same brilliancy, nor do they allow of the same bold and effective treatment.

It is much to be desired that amateurs who can draw, and who have a feeling for this particular style of art, should devote a portion of their time to its execution. They will find it to be extremely agreeable and pleasant, and the few difficulties which they meet with in

their first attempts will be readily overcome by perseverance, or by applying for assistance and advice to gentlemen engaged in the pursuit of this interesting profession.

Moulded and Cut Glass.—Flint glass is now very commonly blown in moulds, and this art has been brought to such perfection that moulded decanters and tumblers have an appearance very similar to that of cut glass. The moulds are always made of metal, and so constructed that they open out into two or more pieces, which are generally hinged to the bottom of the mould. The workman places it on the ground, and fixes it by standing on projections from its side. He then gathers a suitable quantity of glass on the end of his blowpipe, which he places in the mould, and the side of the glass touching it will thus have impressed upon it whatever form is engraved on it. After the glass has become hard, the mould is opened, and the glass vessel is removed and annealed.

When it is desired to cut a design on the outside of a tumbler or wine-glass, the vessel is, in the first instance, blown of a thicker substance than if it is to be left uncut. The necessary shapes, which are usually in facets, are cut upon it by the action of sand and water, a lathe of a very simple construction being used to give a rotary motion to cutting discs, made of stone, and kept continually moist by water dripping on them, so that when the glass is pressed against them, the required portion of its surface is worn away. The usual diameter of these stones is about 10 inches. After the rougher stone has been used, a finer kind of sand-

stone disc is employed, or a disc of slate, upon which sand and water are allowed to drop, and the already roughly cut surface is, by their action, partly polished. Copper discs with flattened circumference are used for polishing the glass, and for this purpose emery mixed with oil is applied to the edges of their circumference.

Ground Glass is made by rubbing the surface of glass with sand and water, just as in the first operation of plate-glass polishing. But a very ingenious method is now generally carried on for grinding glass, by placing it in a cradle, so that it can swing from side to side; sand and water are placed upon the glass, and it grinds itself, so to speak, by this operation.

Annealing and Devitrification.—As the word "annealing" has been often used in this article, it will be well to explain what is its action. If a piece of molten glass be dropped into water, it will assume an oblong shape, the lower end of which will be round, while the other will taper off into a fine point. These drops, which have received the name of Prince Rupert's drops, look like pieces of ordinary glass, and if the small end of one of them be broken off, a sort of explosion takes place, and the whole mass flies into a thousand minute pieces, some of which will be found to have been driven to a considerable distance. Here then it appears that when the skin, which is perfect and entire in the Rupert drop, is broken, the bond which held together the constituent particles is broken also, and so they are acted on by a repellent force, and fly away from one another. If hot water be poured into a thick common tumbler, it very generally cracks

it; but if the tumbler be thin and of better manufacture, it will bear almost boiling water without cracking. In the first case it has been badly annealed; and besides this, glass being a bad conductor of heat, from its thickness the heat imparted by the hot water expands the inner surface, while the outer coating, not being warmed, does not expand, and, retaining its original form, is burst. If, however, a tumbler be thick and properly annealed, there is not so much danger of its breaking, when a portion of it is exposed to a considerable rise of temperature. In the case of the Rupert drops, they are not annealed at all, and so there is no cohesive bond between the particles, such as there would be if they were properly annealed, that is, if, instead of being cooled suddenly from the molten state, they were allowed to cool in a heated chamber very slowly. After glass has been heated, the particles of which it is composed take a long time to rearrange themselves, so that in the manufacture of thermometers, it is necessary, after sealing up the bulb and tube which contain the mercury, to allow them to remain for a long time; otherwise the pressure of the air on the outside of the bulb, not being supported by any air on the inside, causes the particles of glass to become more compact, and thus renders the capacity of the thermometer bulb and tube smaller than it was when the thermometer was first sealed. It seems that the process of annealing glass gives time for the particles to arrange themselves in such a way, that when the glass is cold it will not be so liable to fracture from sudden changes of temperature.

If glass, instead of being taken from the annealing kiln at the proper time, be left exposed in the hot part of it, at a temperature just below that at which it softens, it will be found to become gradually opaque on its surface. Some experiments were performed many years ago by Réaumur, who exposed pieces of glass, packed in plaster of Paris, to a red heat, which became gradually opaque, and lost altogether the character of glass, the texture of their material becoming crystalline, and also affected by sudden changes of temperature. Glass treated in this way was called Réaumur's porcelain. All glasses do not undergo this change with equal rapidity, and some do not experience it at all; but the commoner kinds, such as bottle glass, are the best to experiment upon, for the more alumina that it contains—and it is known that bottle glass contains a considerable quantity—the more readily does it undergo this change, which is called *devitrification*. In what it consists is not at present well understood, but it offers a field for investigation which may produce results of very considerable benefit to manufacturers of glass.

Soluble Silicates.—An article on glass in a modern scientific work like the present would not be complete without a notice of the manufacture of, and uses to which, soluble glass has been and may be applied. It has already been mentioned that when silica or sand is fused with an excess of alkali, the resulting glass is soluble in water.

Soluble glass is made on a large scale in three different ways. First of all, if flints, that is, black flints, which are found in chalk, be heated to a white

heat, they lose their black colour and their hardness, and are easily crushed to small pieces ; and if flint in this condition be placed in a wire cage, and put into a jacketed iron digester, that is, an iron digester which has an inner and an outer skin, with a free space between the two, so that steam may be forced into it from a boiler under pressure; and if the digester be screwed down tightly with an iron cover, and steam then be allowed to pass into the space between the two, the temperature can be raised at pleasure according to the pressure under which the steam is introduced. If the valve of the boiler be loaded with a 60 lb. weight, the temperature of the water warmed by the steam will rise considerably higher than that of ordinary boiling water; and if this water be saturated with caustic soda, it will dissolve the flints slowly, forming silicate of soda, that is to say, the silicic acid of the flint will unite directly with the soda of the solution, and silicate of soda will thus be obtained. For certain applications, the silicate so formed is not sufficiently pure, because the soda used often contains a certain amount of sulphate, which will remain with it in the solution of silicate that is drawn off from the digester. This sulphate is very objectionable for certain applications of silicates, because it crystallizes out, and so destroys the substance, which the silicate is intended to preserve.

Another and a much better method is to heat together the silica in the form of sand with alkali, either potash or soda, in a reverberatory furnace, and as the glass becomes formed, to rake it out into water,

and then gradually to dissolve it by boiling in suitable vessels. Here the sulphate, if it existed in the alkali, is decomposed by the silicic acid, and the sulphuric acid passes off through the flues of the reverberatory furnace.

There is also a very ingenious way of making silicate of soda, discovered by Mr. Gossage, and performed as follows: common salt is heated to a high temperature and volatilized, and in this condition is brought into contact with steam, also at a high temperature, when a double decomposition takes place. Steam is composed of oxygen and hydrogen; common salt, of sodium and chlorine. The chlorine of the common salt unites with the hydrogen of the steam, and the oxygen of the steam with the sodium, so that hydrochloric acid and oxide of sodium are formed. Now, if these two substances at this high temperature were allowed to cool together, the action would be reversed, and the re-formation of steam and chloride of sodium would be the result; but in the strong chamber lined with fire-clay, in which these vapours are brought into contact, silica is placed in the form of sand made up into masses, and when the oxide of sodium is formed, it unites with the sand to make silicate of soda, and thus is removed from the action of the hydrochloric acid, not entirely, but sufficiently to produce a large yield of silicate of soda.

The properties of silicate of soda, as applied to the arts, are somewhat different from those of silicate of potash, so that one cannot always be substituted for the other. Both these substances are, when in solution and concentrated, thick and viscid, and have the

property of causing paper, wood, &c., to adhere when applied as a gum or glue, and hence have been called "mineral glue." In a dilute state they can be used for coating stone, brick, or cement, and have the power of rendering them for a time waterproof, or nearly so, and of preventing the action of atmospheric influences, which too often produce the decay of some of the softer stones used for building as well as for cement. It has already been stated that when carbonic acid is passed through a solution of silicate of soda, silica will be precipitated. Now, inasmuch as there is carbonic acid in atmospheric air, when these solutions are applied to the surfaces of a building they will be acted upon slowly by the acid, and silica will be precipitated in the pores of the material to which the silicates are applied. But this operation is extremely slow, and before it can be thoroughly completed, the silicates, being soluble, will get in part dissolved out by rain and moisture, and it is therefore advisable to use with them some material which will, by a double decomposition, form a silicate insoluble in water. The silicate, however, which is formed, should have cohesion amongst its particles, so that it will not only adhere to the stone itself, but its own particles will adhere to one another when it gets dry. Various methods have been tried to cause this insoluble substance to be formed upon the surface of stones, so as to fill up its pores and to make a protecting cover for it; but most of them have signally failed, because the new silicate produced by double decomposition has not had the necessary coherence amongst its particles. If a solu-

tion of chloride of calcium be added to one of silicate of soda, a silicate of calcium will be precipitated, and it was therefore thought that by applying to a stone successive washes of silicate of soda and chloride of calcium, an insoluble silicate of calcium would be produced in the pores and on its surface. It is true that such a silicate is precipitated, and that, if the silicate employed be in excess of the chloride of calcium, the particles will be glued together by the adhesive powers of this silicate when it dries; but then the action of moisture upon it is to cause it to run down the surface of the building, and set free the particles of silicate of calcium which it held in combination. Other processes of the same kind have been tried, and with similar results; one great difficulty in the way of the success of this method of applying silicates being that, from the peculiar colloidal or gluey nature of the silicate, it does not penetrate to any considerable depth into the stone, and if laid on first, prevents the penetration, as far even as it has itself gone, of the solution of chloride of calcium. If the chloride of calcium be used before the silicate, it will penetrate farther than the solution of silicate is able to reach, so that it is impossible to obtain, even supposing the substance to be used in equivalent proportions, a complete decomposition of the one by the other.

The great object to be attained in the preservation of stone by any silicious process is to use *one* solution possessing the substances which, when the water has evaporated, will form a perfectly coherent mass for the protection of the stone surface. The depth of penetra-

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tion, if it is sufficient to protect the outside of the stone from the disintegrating action of the atmosphere, need not be carried much more than one-sixteenth of an inch below the surface, for when old stones which have long been in positions in buildings, and which have not decayed at all, are examined, it will be found that they are covered with an extremely thin film of a hard substance, not thicker than a sheet of writing paper, which has for ages protected and preserved them from decay. This film is produced by a determination from the inside to the outside of the stone of a silicious water, which existed in it in the quarry, and which, when the stone was placed in the building, gradually came to the surface, the water evaporating and leaving behind it a thin film of silica, or of a nitrate—most likely the latter.

If alumina be fused with potash, aluminate of potash, soluble in water, is made; if, however, the solution is too concentrated, a certain quantity of the alumina will be precipitated; but if it be dilute, the whole of the alumina will remain in solution. When aluminate of potash of specific gravity 1·12 is mixed with a solution of silicate of potash of specific gravity 1·2, no precipitate or gelatinization will take place for some hours; the more dilute the solution, the longer will it remain without gelatinization, and of course the thinner it will be, and the greater power of penetration it will have when applied to a porous surface. When solutions of aluminate of potash and of silicate of potash of greater density are mixed together, a jelly-like substance is almost immediately formed, and sometimes even the

whole mass gelatinizes. If this jelly be allowed to dry slowly, it will contract, and at last a substance will be left behind sufficiently hard to mark glass, though the time for this hardening may be from one to two years, and on examination it is found that this substance has very nearly the same chemical composition as felspar, and is perfectly insoluble in ordinary mineral acids. Now, suppose a dilute solution of this mixture to be applied to the surface of stone, the silicate and aluminate of potash will gradually harden and fill up the interstices of the stone; and as both the substances entering into combination are contained in the same solution, they will both penetrate to the same depth. Inasmuch as the artificial felspar is not acted upon by destructive agents which would disintegrate the stone, it becomes a bonding material for its loosened particles, and at the same time gives a case-hardening to the stone, which no doubt will as effectually protect it against atmospheric influences as in the case of the hardening of the natural one. We have a tolerable guarantee that this will be so, if we consider the number of enduring minerals into the composition of which silica, alumina, and potash enter, and also of the almost imperishable character of granite, which is so largely composed of felspar. Many experiments have been performed on an exhaustive scale with these materials, and in every case it has been found that they have answered the expectation of those who have thus tested them. It is, however, necessary to state, that in making these experiments, great care must be used to employ the mixed substances in solution before gelatinization has

set in, for if this has occurred, even to the slightest extent, a surface coating is formed on the stone, which, not having formed a bond with it, easily rubs off.

Another application of soluble silicates in this or other forms is to render walls of buildings which are porous, waterproof. A colourless, transparent material which can effect this object is doubtless desirable, as anything like an opaque wash, if applied to brickwork, would destroy the colour of the bricks, and therefore the character of the building constructed with them. The silico-aluminate of potash may be used for this purpose, as above directed; and even silicate of potash alone, provided it be in sufficient quantities, will answer well, if from year to year, for two or three years, the application be renewed, so as to fill in spaces wherever the silicate may have been in part dissolved out. When the silicate of potash alone is used, the action of the carbonic acid of the air in precipitating the silica is depended on, and while this action is going on, portions of the silicate not acted on will be dissolved out.

Many years ago an effort was made in Germany to revive the ancient art of fresco-painting, and with very considerable success. It was found, however, that our climate is not suited to the permanence of this method of decoration, nor indeed is any climate absolutely suitable, because in fresco-painting the surface only of the lime is coloured with pigments laid on, so that any influence which would destroy the lime surface would cause the removal of the pigments; and from the porous nature of the surface of the work after

it is completed, absorption of moisture will from time to time take place, causing the adhesion of dirt and other foreign substances which may fall upon it, and which it is almost impossible to remove without detriment to the picture. Dr. Fuchs, of Munich, discovered a method of painting with soluble silicates, which has been tried with considerable success in Berlin by the late Professor Kaulbach. On a properly prepared ground, the painting was executed in colours mixed with water, which, when dry and the painting finished, were fixed to the wall by the application of soluble silicates. For the preservation of the work, Dr. Fuchs mainly relied upon the action of atmospheric carbonic acid. Now, when carbonic acid acts upon silicate of soda or silicate of potash, we have already seen that the silicic acid is precipitated in the hydrated form, and that the carbonic acid unites with the soda or potash to form carbonate of soda or carbonate of potash. These substances being left in the painting and penetrating to a certain depth beneath its surface, must find their way out, and in almost every instance have done so in the form of an efflorescent substance, which has caused the picture to have the appearance of being mildewed over its surface. Sometimes, however, sulphates occur in the ground, and then sulphates of soda and of potash have been formed, injurious to the permanence of the surface of the picture, because they crystallize and force off portions of the lime and sand of which the surface is composed. The effect of the efflorescence of the carbonates on the surface of a silicious painting may be seen in the famous picture of the meeting of Wellington and Blucher, in

the House of Lords, painted by the late Mr. Maclise, R.A. When, however, the solution of aluminate and silicate of potash is used with the pigments on a properly prepared ground, there is no fear of this efflorescence taking place, and paintings executed with it have stood for many years without giving any signs whatever of decay.

To those interested in this subject, it is desirable that they should perform a series of experiments themselves, and ascertain the best methods of practically applying this vehicle in the execution of large mural paintings. They will find that, although at first they may meet with some difficulties, yet after awhile these difficulties will vanish, and they will have a material to work with, which will meet all their requirements.

In an article so brief as the present, it is impossible to enter fully into all the details of the manipulation of this particular process of painting; it is, however, most desirable to give a short account of the method of preparing the ground and of applying the colours, leaving the rest to be learned from practical experience.

Angular fresh-water river sand, well washed, should be mixed with sufficient lime to cause it to adhere to the wall on which it is placed, and this in all cases should be freshly plastered in the ordinary way. No plaster of Paris (which is sulphate of lime) should be used in the preparation of the groundwork. The coating of fine sand and lime is laid on to a depth of about an eighth of an inch, and when dry, an application of dilute silicate of potash should be made, in order

to bond together the particles of sand which, owing to the employment of so small a quantity of lime, can be readily brushed off. As soon as these particles are well fixed together and do not come off when the hand is passed over the surface of the wall, the ground is in a fit state for the commencement of the painting. The colours should be used with zinc white, and not with lead white, and, of course, they must be in the state of fine powder, and not ground up with oil or any such material. The artist can use his mixture of silicate of alumina and aluminate of potash of the strength already described; he may, when desirable, dilute it to a certain extent with water, but he should not do so too much. He can then paint with it just as he would with water in water-colour painting; and if he finds that any portion of his colours, after they are dry, are not sufficiently fixed upon the wall, he can then with a brush pass over them a coating of the clear liquid, used a little stronger. When the whole work is finished, it will perhaps be desirable to give it one or two coats of a very dilute solution of silicate of alumina and aluminate of potash. After a time, owing to the contraction in drying of this material, it would be advisable—say, after the lapse of two or three months—to again apply a coat of it somewhat stronger; and again, if after a year, or more than a year, it should appear that any portions of the surface were becoming loose, another application of the mixed silicate of alumina and aluminate of potash to these loosened parts alone will be desirable. This repetition may appear to some to be an objection to the process,

but it is not so, however; for in the formation of those natural substances, such as flints, which we find so hard, no doubt a very great lapse of time occurred in the induration of the gelatinous silica which formed them. Neither do we object from time to time, at intervals of years, to renew the coats of varnish on oil-paintings, in order to preserve them or to bring out afresh the brilliancy of their colours.

The soluble silicates are frequently used as bonding materials in the manufacture of artificial stone and cement, very good results having been attained. The objection, however, to their employment for these purposes is the expense of the material of which they form a constituent part, and it seems almost impossible ever to bring it into competition with dressed natural stone. But for ornamental purposes, from the plastic nature of the substance when in the wet state, it can be pressed into moulds, and wherever plaster mouldings are admissible, no doubt this material would be useful for certain kinds of ornamentation. Some years ago, Mr. Ransome, of Ipswich, after having made his artificial stone with sand and silicate of soda, heated it in ovens, so as to produce a hard and semi-vitrified mass. A church, the mouldings of which are made of this stone, may be seen at the bottom of Pentonville Hill, London; and certainly as to durability, there is no doubt that the substance has answered very well. But from difficulties in manipulation and other reasons, that gentleman gave up this method of making artificial stone, and is now working another process which yields far better re-

sults. Silicate of soda is mixed with sand (generally Aylesford sand), and after the mixture is moulded and dried, it is exposed to the action *in vacuo* of chloride of calcium in solution. Whether the whole mass is placed in a vacuum chamber and then charged with chloride of calcium; or whether a vacuum is formed on the under side of the substance, and the chloride of calcium solution caused by suction to filter through it, is uncertain. However, whatever be the manipulative processes, the result is the same, and appears to be extremely satisfactory.

Soluble silicates produce very remarkable results when mixed with certain substances. If silicate of soda or potash be mixed with white lead, in a very short time it sets into a hard substance, just as does plaster of Paris when mixed with water. If powdered pumice-stone or sand, in the proportion of eight parts to one of carbonate of lead, be mixed together with soluble silicate, a very hard and coherent mass is obtained, and there seems no reason why a mixture of this kind, in which pumice-stone is used, should not be employed for the purposes to which pumice-stone is usually applied. It would have the advantage of being easily moulded into forms, so as to suit mouldings which might by it be much more accurately and expeditiously smoothed down (as in the case especially of picture-frame mouldings), than they can be by the ordinary pumice-stone.

Another very important application of soluble silicates is the rendering of wood incombustible. Many experiments have been performed which show

that when wood is thoroughly impregnated to a depth of a quarter of an inch or more with silicate of soda, it will not flame, but will only char. Now, supposing that the constructive timbers of a house were worked, and then placed in suitable vessels and saturated with silicate of soda, they would then be rendered practically fireproof, or at least it would take a very prolonged exposure to heat to cause them to smoulder away, while at no period of this time would they burst into flame. From the peculiarly gluey nature of these soluble silicates, they do not penetrate readily into porous substances; it has therefore been suggested that the impregnation of the wood should take place in vacuum chambers, just in the manner that the creosoting process for preserving railway sleepers is at present performed. It is most certainly advisable that the wood should be worked before being exposed to the silicating process, for that would render it so hard that it would considerably increase the cost of labour in cutting and planing it.

At the commencement of this article it was stated that silicic acid, or silica, could be made soluble in water. Some very interesting experiments were performed by the late Dr. Graham, Master of the Mint, which gave rise to the discovery of the process of dialysis. If some silicate of soda be mixed with water, so that not more than 5 per cent. of silica be in the solution (rather less is better), and if some hydrochloric acid be then added in sufficient quantity to make the liquid distinctly acid, and the mixture be placed

in a dialyzing apparatus, the chloride of sodium formed by the union of the chlorine of the hydrochloric acid with the sodium of the silicate of soda, will pass out through this dialyzing membrane, leaving hydrated silica behind, which will remain in solution in the water with which the silicate was mixed. The dialyzing apparatus is constructed in the following manner: a sort of tambourine ring is made with guttapercha, in place of wood, from 8 to 10 inches or even more in diameter, the depth being about 2 inches. Another ring of guttapercha, about an inch deep or even less, is made so as to fit tightly outside the tambourine; a piece of vegetable parchment is then moistened and placed over the tambourine, and the thinner ring is pressed over it, so as to secure it tightly. This is the dialyzing vessel, and it is into this that the mixture of silicate and hydrochloric acid must be put. The solution should not be more than an inch deep in the dialyzing vessel, which is then made to float upon distilled water in a larger vessel of suitable size. The distilled water should be changed every day until no precipitate can be obtained in it with nitrate of silver, and when this point is arrived at, all the chloride of sodium will have passed through the vegetable parchment into the larger vessel of water, and nothing but silicic hydrate will remain behind in solution. If this liquid be allowed to stand for some time it will gelatinize, and later on the jelly will contract, becoming extremely hard, so that lumps of it, when broken, will in their fracture resemble that

of flint. No doubt, at some future period, some one will discover a method of rendering this condition of silica useful in the arts.

Soluble silicates are very useful as detergents. A small quantity of silicate of soda mixed with hard water renders it valuable for washing purposes. Silicate of soda is also used in the manufacture of the cheaper kinds of soap. We can hardly speak of it as an adulteration, because it renders the soap with which it is combined much more powerful in its cleansing action. I suggest to those interested in the application of science to the arts, that this subject will no doubt well repay experimental investigation.

FURNITURE AND WOODWORK.

By J. H. Pollen, M.A., South Kensington Museum.

I propose in the following pages to give some account of the materials used in making furniture, and of the arts applied to its decoration. From the earliest ages of society, when men moved about in tribes, they had in their tents of camels' hair simple necessaries, such as their wants required. Before they were gathered into distinct nations, or cities built with walls and gates, there were still certain human wants that must needs be supplied; and the objects that were needed to enable mankind to live with convenience and decency were found in their furniture. To this very day we may see Arab tribes wandering over sunny deserts, seeking pasturage, sowing here and there an acre of wheat or barley, or gathering dates. Their camels and dromedaries are their waggons, their horses are their friends, their families and those of others that make up their tribe are their only nationality. Yet they furnish in some sort the temporary homes which they shift from one spring of water to another, as the patches of grass or grain grow up and ripen. Their chief wants are a cloth strained over three staves to make a house, mats or carpets to lie on, a few bowls to cook in, saddles of wood, and a few baskets or chests, made of light sticks fastened together.

In this way a gipsy life reduces wants to the fewest, as it admits of the smallest amount of stowage and carrying conveniences.

Following up the subject, we shall find this primitive type of furnishing carried out, with growing splendour, in later periods of history by bodies of men placed in a like condition of movement and pressure, namely, armies. In the West and in the East, in ancient and mediæval times, armies have been followed by enormous trains of camp followers, by whom costly furniture, hangings, vessels of plate, and other luxuries, have been carried for the convenience of the leaders and warriors of the hosts; and of course this splendour was the measure of the state and magnificence kept at home. The wealth or feudal state, shown in the furniture of these castles and palaces, extended not only to halls and rooms, but to dresses, and armour, weapons, the furniture of horses, tents, and other objects that could be carried on distant expeditions.

Ancient nations have been as well, perhaps more splendidly, if less conveniently, provided with furniture for their houses than modern ones. It happens that there are distinct records of many kinds, showing what wealth and elaborate decoration some of the oldest races, such as the Assyrians, the Egyptians, the Persians, and the Greeks, bestowed on their thrones, beds, chairs, and chariots. It is needless to quote here the descriptions in Herodotus, in Homer, in the Scriptures, and in many ancient authors, of the costly nature of these objects, the possession of which was not considered astonishing or exceptional. Beds of silver and gold

are mentioned in Esther i., and the curtains of the bed of Holofernes were covered with a canopy of purple and gold, with emeralds and precious stones (Judith x. 19; Esther i.). Modern princes in India continue to devote their jewels and gold to similar uses. It must be borne in mind also, that this kind of splendour is an investment of property in times and countries in which banks, insurance offices, government funds, and other organized means of investing money are unknown. Carlyle records of Frederick the Great, that silver ornaments were kept in his palace, and turned to account under the exigencies of war.

Silver, if not gold, has been used occasionally during most periods of history, for seats, tables, even the frames of pictures and mirrors. But of furniture generally, wood is the readiest and most proper material. It is handy, easily worked, light to carry about, and may be manufactured with or without decorations of carved work, or of any other kind. Hence, in giving an account, whether historical or mechanical, of furniture, I class it under the more general head of woodwork. Any other materials, either for the framing or ornamentation of furniture, are exceptional. The remarks now to be submitted to the reader will refer to wood that is manufactured, though I shall not enter on the interesting subject of wood structure, which has been applied to such noble and elaborate uses, and of which such splendid monuments of many periods still remain for us to study.

Most of the methods used for decorating woodwork made up into furniture are still in regular use, and

the processes of putting it together are the same as they have always been. The reader may satisfy himself on this point any day by a walk in the Egyptian rooms and in the Nineveh galleries of the British Museum. In both these sections of that wonderful collection there are remains of woodwork and of furniture, made of wood three or four thousand years old, such as stools, chairs, tables, head-rests or pillows, workmen's benches of Egyptian manufacture, fragments less complete of Nineveh make that have been portions of various utensils, and precious articles of sculptured and enamelled ivory, that have been inserted into thrones and chariots. These pieces of furniture have been mortised together, or joined by dowels, dovetailed at the angles, glued, nailed, or, in short, made up by the use of several of these methods of junction at the same time. And no great changes have been introduced in the various ways of ornamenting furniture. The Egyptian woodwork was painted in tempera, and carefully varnished with resinous gums. It was inlaid with ebony and other woods, carved, gilt and, perhaps, sparingly decorated with metal ornaments. Mediæval furniture was put together with mortises, tenons and glue, and was gilt and painted; the painting and gilding being laid on a ground prepared with the utmost care, and tooled and ornamented in the same way that bookbinders ornament leather. At a later period, a beautiful manufacture was carried on in various parts of Italy; a sort of mosaic in very hard stone, such as agate, lapis lazuli, and other precious materials. The Italians

also used these beautiful stones inlaid in ebony. But the furniture most valued in modern times has been that which owes its name to Boule, a French artist of the seventeenth century; and the marquetry, or wood mosaic surface decoration, which reached so high a standard of excellence during the last thirty years of the eighteenth century in France.

The former of these two classes of manufacture is made by foreign houses still in France, and occasionally in England, but it is no longer a regular trade in this country. The work made, if not originated by Boule (and I am inclined to think that he was not the first maker), was a marquetry, or surface decoration, not composed of various woods, but of tortoiseshell and brass, with the occasional introduction of other metal, and with metal enamelled blue and other colours. The materials principally in use, however, in Boule marquetry are tortoiseshell and brass. In the older work, viz. that of the seventeenth century, the tortoiseshell is dark, and left in its natural hue. In later Boule, called new Boule, the tortoiseshell is reddened by colour, or by gilding laid under it. There is much grace and variety in the delicate arabesque designs in which one material is inlaid in the other. Parts of the surfaces are sometimes diapered, as a contrast to the free lines and curves of other parts. The inlaid surface of Boule work is framed in by borders, cornices, or handles of brass or gilt bronze, giving a massive architectural character to the whole.

As this kind of furniture is uncommon in the present day, I need not enter at any length into the kind

of pieces made in that material or their designs, still less into spurious imitations, sometimes seen in this country, in which compositions of gelatine and other materials are substituted for the beautiful tortoise-shell of the genuine manufacture. I shall proceed to enter more in detail into the various conditions of the woodwork and furniture trade, as it is carried on by the higher representatives of the trade in London, Paris, and other capitals of Europe.

For this purpose I cannot do better than follow the example of M. Viollet-le-duc, in his treatise on French furniture in the Middle Ages. He takes his reader on a visit to a furniture maker, who describes the leading particulars of his craft, and the various artisans employed either in framing together, or in adding decorations of different kinds to the finished work, according to the traditions of the artists of the period.

A walk through the premises and workshops of one of the leading firms who control this trade would suffice to show us the present state of the manufacture, taking a few names only in alphabetical order, such as Messrs. Crace, Gillow, Holland, Howard, Jackson and Graham, Collinson and Lock, Morant, Wright and Mansfield. Others could be added, were this intended for more than a sketch of the kind of establishments in question. We enter, for instance, the large manufactory of Messrs. Jackson and Graham, in Oxford Street. In a small yard outside the building are packed huge logs of wood of various kinds, and amongst them one of walnut, upwards of 3 feet square; it is of light colour, and we are told that it is American. There

are three kinds in use in cabinet-making, of which the American is the least valuable, as it is inferior in hue and grain, and on being first cut shows a dull grey tone, instead of the warmer hue generally recognized in walnut-wood. The colour, however, improves; but this kind of walnut is used for cutting out in work requiring solid wood throughout, such as the frames of sofas and chairs. The French walnut is of finer colour and more figured grain, and is used in veneers. The finest of all is the Italian, both for figured grain, colour, and tenacity. Besides walnut, we see also a pile of huge logs of mahogany, beech, and American ash. A 6-ton crane, turning on a pivot, enables the workmen to swing these large masses from the timber waggons, or from their present places, into the lower part of the building, in which a forty-horse steam engine sets in motion three or four sawing machines, horizontal, perpendicular, ribbon saws, planing engines, &c. A log of mahogany, 3 feet square, is being cut into thin plank by the horizontal saw, of which the teeth are not bent, as in most saws, to one side and the other alternately, so as to make a cut wider than the thickness of the rest of the blade and allow it to work with ease. In this case the saw opens only a cut of its own thickness, and a labourer opens the passage for the blade by lifting the plank with a wedge, so that no waste of material is thus entailed. The perpendicular saw has three blades, and cuts a log of American ash into planks, three at a time, the teeth being in this instance set in the usual way.

We mount into a set of rooms overhead, in which a

leather band from the engine sets in motion a series of turning lathes. In these lathes the legs of a host of chairs, tables, &c., are being evolved, the general outline being obtained by turning in the simple form. Portions of the legs are to be squared, and the square faces must be evenly graduated. These parts are cut as follows: the lathe and the leg in it are kept at rest, and a revolving tool—in fact, a small lathe with a perpendicular cutter in it, connected by a leather band with a spindle overhead—set in motion by the steam engine. The workman passes this cutter carefully down the four surfaces of the portions to be squared, cutting to a given depth all down, but never losing the angle outlines originally found by the first turning. Another lathe shows legs of this description, both round and square, down the surfaces of which flutings are to be cut. This is done by using a revolving cutter set with horizontal action, which passes carefully along at one level, and is geared by the joiner so as to graduate the width of each fluting, as it descends, if the diminishing size of the support or leg requires it.

In this shop are an engineer's bench, for repairing the engine or cutters used in various parts of the machinery; a fine-hair endless saw, and on a solid foundation of brickwork from the floor below, a mortise and tenon machine is in course of construction. The solidity of the foundation is required to keep the platform secure, and to avoid unsteadiness from the action of the machine in the lathes on other parts of the floor. A side bench has a simple contrivance for setting, by means of a T square, lengths of moulding

which are to be mitred together. These are carefully cut by hand, and as each piece is set in a frame geared to the angle required, and under the hand of an experienced workman, no inaccuracies are likely to occur. In cabinet-making and joinery of all kinds, the number of angles round which mouldings have to pass is very great, as anyone will see who is at the pains to notice the construction of furniture of the most ordinary kind. Any staring or opening of an oblique joint is destructive of the effect of such workmanship, as it is of the strength of the joint which is glued together, and requires absolute contact of the parts joined.

From this shop, in which most of the rough work is done, and the different parts of pieces of furniture cut out, we pass into the joiners' shop, in which large surfaces of panelling, doors, stair-railings and balustrades, and other larger work are put together. For instance, several benches are occupied by lengths of wall-panelling in ebony, some of the work being intended to cover the wall of a staircase; it is therefore framed in sloping lines. Each panel is a rhomboid, and none of the sides or mouldings are at right angles to each other. The mouldings have several fine strings, ovals, &c., all specially designed by the architect of the house—as the fittings of well-furnished houses should be. For these, special cutters have been made and fitted to the steam-moulding machine. We ask to see the back of the panelling, and the workmen turn it over. Instead of each panel being held in a groove provided in the stiles and rails, a rebate

only has been cut in the frame, and the panel fits into it from the back (as the stretcher of a picture fits into a picture-frame), while iron buttons screwed into the frame pieces hold the panels firmly in their places. The object of this is to allow for the contraction of the wood with the alterations of temperature. With some woods, however well seasoned, this provision is requisite. This is the more necessary when more than one material is employed. In using ebony over large surfaces, it is found that the lengths required for the continuous rails cannot be procured free from knots or faults; and particular kinds of wood (pear and other material) are stained and prepared to supplement the ebony in these instances. All these materials have been cut out to the requisite thicknesses, stacked under cover for months, or, as in the case of oak, for seven or eight years, or longer still. Before being worked in the joiners' shop, they are further dried in a hot closet, heated by applying to the sides the spare steam of the engine. Pots of glue are kept at intervals in these shops, ready heated by the same means.

We pass on and find table tops in preparation. As no one plank is large enough for tables of great size, it is necessary to select and cut with great care portions of planks, which are grooved and tongued till they make up together the size required. In all these operations great caution is required in the selection and adjustments, so as to secure the perfect endurance of the material without cracks or warping.

In another division of the joiners' shop we come

upon the framework of chairs, sofas, &c. The parts intended to be covered up are usually made of beech—a tenacious, close-grained, but not heavy wood. Some portions of sofas are not meant to be covered, such, perhaps, as the legs and the top, and the outer framework of the seat, and in such cases these are of walnut or other costly woods, and are carved, partly or entirely gilt, as may be required to suit the furniture with which these articles are to keep company.

I may remark here, that though arm-chairs, fauteuils, &c., are made in these establishments, the manufacture of light chairs on a large scale is a special branch of the trade, and mostly carried on at High Wycombe, in the neighbourhood of which town there are extensive woods of beech, and where land and water carriage is at hand to convey these productions to London and elsewhere. While I am on the subject of chairs, it is worth while to call attention to the scope that exists for good workmanship in this particular article of furniture. The essential points in a well-made chair are comfort, lightness, and strength. Of course, as men and women are pretty much of the same proportion all over the world, chairs, of which the seat is about the height of the lower process of the human knee-joints, must be of the same height, but slightly varied in every country. From the habit that so many persons have of throwing their whole weight back, and, as we are told, in some countries, of balancing their persons on the back legs of their chairs and inclining their legs in the direction of the chimney-piece, there is an immense strain on the back joints of chairs. Whether we lean

means, as it passes gradually through the fibre of the linen, and smooth and continuous action is secured by the oil. It is thus laid over the surface of the wood in very fine coats, one over the other, till a glassy surface is obtained, which is air and water proof.

Cabinet-making.—It is by no means easy to lay down the exact technical boundary between what I have been describing as *joinery* and what I am now about to call *cabinet-making.* They are considered, however, as distinct branches or rather, perhaps, different operations of the trade; and in such an establishment as we are discussing, the cabinet-makers and joiners have their own separate workshops and branches, and corresponding separate repositories for storing and drying their woods. Every kind of work is required in making costly cabinets, bookcases, sideboards, commodes, or by whatever name we choose to call the beautiful chests, cupboards, and other artistic receptacles, tables, consoles, brackets, &c., that go to complete the requirements of our modern reception rooms.

The most elaborate method of decorating and finishing woodwork must now be described, viz. that known as inlaying and marquetry. These two processes are distinct, but marquetry furniture has often portions decorated with inlaying, as also carved ornaments and decorations of beaten, cast, or chiselled metal work. This last addition is not generally of the same importance in our modern English woodwork that it was a century ago, and I will describe the former methods first.

Inlaying means the insertion of pieces of more costly wood, stone, or carved ivory into a less valuable

material. The process is as old as any manufacture in wood working of which we possess records. Beautiful plates or blocks of ivory can be seen in the Assyrian Gallery of the British Museum, found at Nineveh by Mr. Layard. They are deeply cut with lotus and other leaf decorations, figures and hieroglyphics, and most of them have an Egyptian character. The ivory figures, too, have been inlaid, and filled up with *cloisonné* enamel; that is to say, the vitrified material has been inlaid into little divisions or channels, the sides and little walls of which have held it in. Remains of these decorations are still discernible, and the thickness of many of these pieces of ivory shows that they have been sunk bodily into woodwork of a solid character.

No such work as this can be pointed out in our London workshops, but patterns and arabesques, both of wood and ivory, are let into solid beds of wood so deeply as to be actually mortised into the main body of the structure. This is done both by our own makers and by the French cabinet-maker, Henri Fourdinois, a prize piece of whose make was bought for the South Kensington Museum. It is not uncommon to insert pieces of lapis lazuli, bloodstone, and precious marbles into centres of carved woodwork, and I may call attention to the use of plates, medallions and cameos of Wedgwood ware, which were frequently inlaid by Chippendale and by the great French furniture makers, or *ébénistes*, of the last century. These are used in the modern satinwood furniture of Messrs. Wright and Mansfield, and I have lately seen a coarser material used, viz. bas-reliefs in *stoneware*, imitations of the *gris*

de Flandres, by Messrs. Doulton. These last, however, may be said to be rather panels set in frames, than pieces let into cavities in wood.

Veneering and Marquetry.—A more effective method of ornamenting woodwork by the use and insertion on the surface of other woods is what is known as *marquetry*. The surface is in this case covered with a thin layer of other woods, fastened on with glue and by strong pressure. Some of the panelling, table tops, and other joiner's work already described, is clothed with a thin slice of more valuable wood. This is called *veneering*. Woods such as ebony, tuya, satinwood, palm, harewood, and a number more, are only to be had in small scantlings, logs a few feet long, and 6 or 7 inches wide. Other woods, of which the grain is most beautifully marked, are cut from roots, wens, and other excrescences of the tree to which they belong, and are only found occasionally, and in lumps of no great size. The contortions of the grain, which make them so valuable and beautiful, are owing to peculiar conditions of growth. In all these cases one plank of wood has to be cut into very thin slices, twelve being cut with a saw, or from eighteen to twenty-two if it is cut with a knife, as in that case no material is wasted by the opening made by the saw. These slices are laid on the surface of well-seasoned wood, and in each of the workshops that I have been describing will be seen a metal table or bed prepared for the process of veneering.

Supposing the object to be veneered to be a large surface—a number of panels, or the top of a table of

ebony, for instance—the substance of the table may be Honduras mahogany. The wood has been carefully seasoned, and the top grooved, tongued, and firmly glued up to the required form. The ebony surface is also carefully fitted together and glued on paper, the surface being left rough, so that the glue may have a firm hold on the fibre of the grain. A corresponding roughness is produced on the upper surface of the mahogany, which is then laid on the metal bed. Glue, perfectly fluid and hot, is now rapidly brushed over the entire surface, and the thin veneer top is laid upon it, and firmly pressed down by several workmen, who then carefully go over the whole with hammers having broad, flat heads; the object of this being to flatten any apparent thicknesses of glue or bubbles of air which would interfere with the perfect contact of the two surfaces of wood. The whole is then placed under a caul or frame that touches it all over, and a number of strong bars are screwed down till the greater part of the glue has been pressed out. The complete union of the surfaces of the woods is effected not so much by the quantity of glue as by the absolute exclusion of the air, and this can only be done by pressure. The whole metal bed or frame in which the veneering is performed is heated by steam, or by gas-burners where the steam cannot be applied. The wood is left for twenty-four or thirty hours, till the glue has been completely set and hardened. The caul or frame is then removed, the paper used to keep the thin veneer together before glueing is scraped off, and the work of finishing and French polishing

takes place. French polish, or careful wax polish, has the effect of keeping out air and damp, which latter might soften the glue and disintegrate the surface veneer. It is to be observed, that such wood as the finest French or Italian walnut is often veneered on mahogany. *It lasts better in this condition than if it was solid;* large surfaces and thicknesses of walnut being difficult to procure without faults. Walnut veneers are applied in greater thicknesses than ebony; and if the surfaces to which they are applied are curved, cauls, or shaped pieces of wood to fit them, are screwed down and held by numerous wooden vices, as in the method already described.

Marquetry is the application of veneer made of different woods, ivory, &c., composed like a mosaic or painting executed in coloured woods. This kind of decoration is of ancient use, was much in vogue during the Renaissance of the fifteenth and sixteenth centuries, and was carried to a great pitch of perfection in France during the seventeenth and eighteenth. It is still practised, and the process may be seen in full activity in the workshops which I am visiting in company with my readers. A very fine and beautiful kind of marquetry (see p. 131) goes by the name of its inventor, André Charles Boule, a French artist, who made a reputation during the reign of Louis XIV. of France, and that of his successor. As this branch of the trade can hardly be said to be in activity at the present time, certainly not amongst our own makers, I will reserve what I have to say on this costly manufacture. In cutting out the forms required for marquetry

decoration, one, two, or more thicknesses of thin wood are gummed or pasted together, according to the pattern required. In many fine pieces of marquetry there are, as in the case of a cabinet or table, portions of the surface entirely occupied by quiet reticulated patterns. As in these cases the same pattern often recurs, several thicknesses of wood can be laid together, and are then firmly fixed in a vice, having pasted over them a piece of paper on which the pattern is drawn. A small hole is bored where it will not interfere with the design, and the end of a thin watch-spring saw is passed through, and then reattached to the frame that strains it out in working order. With this in his hand, the workman carefully follows the outlines of his drawing, which the tenuity of the saw-blade allows the tool to follow into every curve and angle. The thicknesses are then separated with the blade of a knife, and the slices are alternately pattern and ground, so that a set of patterns and a set of matrices of each wood are ready for use, and can be applied either on different parts of the same, or on two separate pieces of furniture. If a flower or other ornament is required which will not be repeated, two thicknesses only will be cut together. It is necessary that the same action of the saw should cut out the pattern and the ground in the two woods required, so that they may fit exactly.

When all the portions of the design are cut out, they are pasted on paper, and can be fitted together like mosaic. A little sawdust from the woods used, and a very small quantity of glue, join the edges and

fill up the fine openings made by the saw; and in this way the whole surface of the marquetry is laid down on paper. In the case of flowers, heads, architectural or other designs, some slight additions, either of lines to indicate stalks, leaf-fibre, or the features of the face, are made with a graver, and stained; or gradations of a brown colour are given, in the case of white or light-tinted wood, by partial burning. It was formerly the custom to burn with a hot iron, but a more delicate tint is given by using hot sand, and this is the best method of tinting beech, lime, holly, box, maple, or other woods which are nearly white. There remains nothing but to rough the surface of the furniture, and to lay down the marquetry on it precisely as in the case of plain veneering. When the glue is dry and hard, the pressure is taken off, the paper which is on the outer surface is scraped away, and the whole rubbed down to a fine surface and French polished. The most beautiful work of this description was made in France by Riesener and David, during the reigns of Louis XV. and Louis XVI. Besides graceful and delicate *design*, which these artists (for such they were) thoroughly understood, the beauty of their work owes much to their charming feeling for colour. Both used light woods, such as maple, holly, box, lime, &c., and laid brown woods, such as laburnum and walnut, on this light ground. Sometimes architectural compositions in the manner of Pannini, a favourite Roman painter of the day, were designed over the doors or flaps of secrétaires and cabinets, or busts, medallions, baskets of roses, &c. The charm of the work is the

grace and repose with which these simple decorations are laid on. Compare some of the work of Riesener and David, on the cabinet doors in the collection of Sir Richard Wallace, with the glaring contrasts, the gaudy, often discordant colouring, and the crowded compositions of modern marquetry, at least of most of it. There is a tenderness of treatment, grace and harmony of colour and arrangement throughout the former, which is wholly wanting, and which no lapse of time will add to the latter. These criticisms, however, are not meant to be applied to the products of the leading houses now under review, but the reader who has taken an observant stroll through the collection of furniture of Sir Richard Wallace, will find abundant contrasts as he walks along the streets of London.

In order to illustrate my remarks on the processes of colouring woods by burning or etching, I may point to a large writing bureau, or secrétaire, belonging to Sir Richard Wallace, made by Riesener, in 1769 (and signed), for Stanislaus, king of Poland. It is decorated partly with reticulated pattern work, partly with the royal cipher in medallions, and with other medallions containing emblematic figures, such as a carrier pigeon, a cock, the emblem of vigilance, or the head of a girl placing her finger on her lips, an emblem of silence. All these medallion figures are broadly laid in, the very slightest and most delicate tint only being added to represent shading, while the drawing is a single line lightly pencilled.

The materials used in the best marquetry are lime, holly, box, maple, beech, poplar, for white; pear, la-

burnum, palm (cut across the grain), lignum vitæ, walnut, teak, partridge-wood, for brown; wood called in the trade fustic, satinwood, for yellow; tulip, purple-wood, amboyna, mahogany, thuya, logwood, camwood and varieties of these woods, for red; for ebony black yellow, and green. Greens and blues are also stainec with metallic dyes. The finest of the old work may be called studies in brown and white, and the rec woods are used sparingly; the dyed woods still more so, nor can they be said ever to be really effective.

As we pass through Messrs. Jackson and Graham's cabinet-making shops, our attention is called to an elaborate cabinet of marquetry, in patterns of Orienta character, after designs by the late Mr. Owen Jones It has an architectural front, with detached columns and groups of architectural mouldings, some of them pu together with the lines of moulding in woods of con-trasted hue, an element of ornamentation that seem to take from the unity and completeness of cap o corona mouldings. The little columns of an inch and a half diameter are entirely covered with reticulatec pattern in different woods. As the shafts are tapering so the reticulated patterns have to be graduated in size from top to bottom. This is a feat of most diffi-cult execution, nor is this the only difficulty in thi portion of the design. The marquetry in the instanc of these columns has to be wrapped round each circula shaft; and each edge, therefore, of every portion o pattern and groundwork has to be sawn out with be-velled edges, so that when rolled, the inner edges mee and the outer edges remain in contact, which woul

not be so were they not bevelled: the contrary would happen in that case, and the outer edges would start in sunder. These columns are two feet and some inches high, and the little reticulations of pattern recur many dozens of times. The conditions of which I speak have to be carefully observed in the case of each. The pattern, too, is graduated, as above stated, so that they have to be sawn out by separate cuttings—a most laborious and costly operation. In passing along the shop, we come to a bench in which one of these columns is in the hands of a workman, who is inserting pieces of hard wood, out of which he has to carve the volutes and foliations of the capitals.

The cabinet-makers' shop abounds in works of laborious and difficult execution such as this, and several foreigners, French, Danes, and men of other nationalities are amongst the workmen of these finer operations. We make acquaintance with an admirable craftsman of the name of Anderson, a Dane, who has been eight years in the service of the firm, and it is from his hand, or under his supervision, that these more difficult pieces of marquetry have been turned out. All these establishments are provided with a staff of gilders, for gold enters largely into the ornamentation, not only of looking-glass frames and the like, but also of wooden furniture, to which it is continually added as an enrichment.

We miss in the great English houses one of the most costly and beautiful elements in the adornment of furniture, and that is, the fine moulded and chiselled bronze work, always gilt, which enters so mainly into

the decoration of fine old French marquetry. The English furniture makers of a century ago were not so behindhand, and old carriage door-handles and furniture had mounts of gilt bronze. Probably the French were always superior to us in this kind of skill. They still produce good work of this class, cast and afterwards cleaned and tooled with the chisel, but it is not equal to the work of the same description by Gouthière, the famous *ciseleur* of Paris in the last century.

We must not pass over in silence a beautiful kind of furniture which was in fashion a century since, and has been revived with good effect by Messrs. Wright and Mansfield, viz. satinwood furniture. In the time of Chippendale, Sheraton, Lock, and other great cabinet-makers, contemporaries of the French artists Riesener, Gouthière, and David, satinwood was imported from India. It was made up by veneering, and was decorated with medallions, some of marquetry, some of Wedgwood ware, after the model of the French inlaying of Sèvres porcelain plaques, and in some instances painted with miniature scenes like the Vernis Martin, called after a French decorator of the name of Martin. Old examples of satinwood furniture, such as tables, bookcases, chests of drawers, &c., are not uncommon, decorated in one or more of these methods. Cipriani and Angelica Kauffmann were employed amongst many others in painting cameo medallions, busts, Cupids and so forth for satinwood furniture. Messrs. Wright and Mansfield have revived this work, and sent a cabinet of large size to the Paris Exhibition of 1867, decorated with medallions, swags, *ribbons*, &c., partly in marquetry of coloured woods,

partly in plates of Wedgwood ware. The piece is further set off by carved and gilt portions, not, however, sufficiently attractive to add greatly to the effect of the piece, which is gay, cheerful, of beautiful hue, and excellent workmanship. It is in the South Kensington Museum.

I have alluded to the furniture of Boule. It began to be made somewhere about 1660, and was perhaps the earliest start taken in the more modern manufacture of sumptuous furniture, and was, I am disposed to think, a great advance and improvement, rather than an absolutely new invention, for pieces are found of a date too early to have been the actual work of Boule. André Charles Boule made furniture of simple, but dignified forms, veneered with tortoiseshell and brass. Several magnificent examples can be studied in the Wallace collection. When the tortoiseshell is dark and rich in hue, the brass of a good golden yellow, and the designs carefully drawn, Boule work seems to equal in splendour, though not in preciousness, the gold and silver furniture of the ancients, and the inlaid work of agates, crystals, amethysts, &c., with mounts of ivory and silver made in Florence in the sixteenth century.

Boule made great presses and cabinets with pedestal tops, on which were those stately clocks of which we occasionally meet specimens, with embossed gilt faces and arched frames, mounted with groups of figures, often of noble design. Boule work is made occasionally by French and other foreign houses, but it is costly, and the rich relieved portions, such as the hinge and *lock mounts,* the salient medallions, masks, &c., set

in central points of the composition, are either copies or imitations of old work. They lack the freshness, vigour, and spirit of the old French metallurgy.

A spurious kind of Boule is made with a composition in place of the tortoiseshell. Boule himself died in 1730, at the head of the royal factories.

Parquet Floors.—There is a somewhat remarkable fact which I may as well discuss here. How and why is it that our English joinery and cabinet-making establishments so rarely make parquet-floors, that is, floors of oak, framed together in flat ornamental panelling, with or without additions of walnut, ebonized wood, &c.? I will not undertake to say that no firm ever does turn out this important requisite (as I must take leave to call it) of a well-furnished house, as witness Messrs. Howard; but practically it is not an English industry, and what is laid down in English rooms is made abroad. In our great industrial exhibitions in London, 1862, and Paris, 1867, these productions have been matter of exhibition by almost every nationality that contributed to the show, our own excepted. The French, Germans of every State, Swiss, Italians, and notably the Belgians floor their rooms with oak floors, carefully and ornamentally laid together, or parqueted, while the proprietors of rich houses in England, so liberal in furniture and arrangement, are generally content to see their rooms floored with deals, and at the utmost lay down a border or edging of a foot or two round their state rooms in this material. Yet, oak is not expensive or scarce, and the habit of keeping floors always covered with Brussels carpet tacked down

is not the cleanest imaginable. The fact, however, remains.

Amongst the many competing nations, the preference of jurors and reporters has been given to Belgian flooring of this kind. It is beautifully made, of well-seasoned wood, and in large pieces, 4 feet or so square, which can be laid down with less trouble than if it is in smaller sizes.

All the woodwork that I have passed under review thus far in joinery and cabinet-work, is of *hard* woods. Much, however, of our modern furniture is of a less valuable description, and is made of pine, American birch, Hungarian and other ash. Pitch-pine, an exceedingly hard wood, difficult to dry, and with a disagreeable propensity to crack if not very well seasoned, is also used, and a beautiful material it is. Some small quantity of bedroom furniture in birch, oak, and ash is made in the workshops that I have been describing. As a general rule, however, this manufacture of soft woods is a separate branch of the trade. To see soft wood, such as pine, made up into admirable bedroom furniture and French polished till the grain of it shows much of the delicacy and agreeableness of satinwood, we should pay a visit to the works of Messrs. Dyer and Watts, in Islington, and to other houses that occupy their time exclusively in work of this kind. It is clean, cheerful, and, by comparison, cheap; is ornamented (in the works of Messrs. Dyer and Watts) with neat lines of red, grey, and black, some of the lines imitative of inlaid wood. It is popular, and if we proceed from the workshops of

Messrs. Graham, Holland, and others, to their show-rooms and warehouses, we shall find this deal furniture for sale, though they do not profess to make any of it. Less costly fine furniture is painted green, or white, or in imitation of other woods, a practice that all modern nations seem to carry on.

The number of hands employed on these large cabinet-making and furnishing establishments is very considerable. Not only are the workshops just described well provided with joiners, cabinet-makers, and turners, but upstairs we find upholsterers, cutters-out and workwomen, stuffing, tacking on or sewing on the covers of chairs, sofas, &c. There are various methods of stuffing seats or cushions; for instance, some have full round tops and edges, and others a French edge, i. e. the chair seats have a delicately kept edge, which the weight of the sitter does not flatten down. It looks as if lined with whalebone, like the stocks of forty years ago, in which the necks of the last generation suffered so much. The edge is given by sewing the horsehair stuffing in a series of carefully made ridges, each giving support to the one which forms the edge, and this keeps the material on the edges from being pressed into the main body, as it were, of the stuffing. In another part of the premises are packing cases, carefully filled with all sorts of household furniture, prepared for journeys of very various length. Indeed, it is no uncommon occurrence for the entire furniture of palaces and yachts to be ordered from one of these firms by the courts of foreign potentates in every corner of the world. Last year we saw chairs,

tables, sideboards, &c., at Messrs. Holland's, for the new steam yacht of the Emperor of Austria; while Messrs. Jackson and Graham have been furnishing, not long since, the palace of the Khedive at Grand Cairo.

To execute, with certainty and promptitude, orders such as these, both premises, plant (such as wood and machinery), and the command of first-rate hands, must be abundant. Painters, gilders, carpenters, paperers, and a miscellaneous assistant staff are required to pioneer the way for the more costly work, or to make all good behind it. The firm of Jackson and Graham, for instance, employs from six hundred to a thousand hands, according to the time of the year or the pressure of orders; and pays out close upon 2000*l.* per week as wages, when all these hands are in full work; and to highly skilled craftsmen (independently of designers), occupied on the production of the most costly kind of furniture, 60*l.* to 230*l.* per week. The great French establishments do not carry on business on so large a scale, nor do they undertake the complete furnishing of houses in the way that I have described, or attempt so many different operations under the same management. It is the variety and comprehensiveness of these operations, that is so profitable as a speculation. Such a business requires, as it need hardly be said, a large capital, and must be liable to fluctuations.

If we turn from our own trade to that of our neighbours, we shall find little difference in the character of the objects produced. France, on the whole, must be said to lead the fashions. We have our own national tastes to satisfy in the interiors of our houses,

but we have little that is distinctly national in the productions of modern woodwork. French Renaissance designs in woodwork, and the produce of the looms of Lyons in hangings, serve to give the key to this school of domestic and industrial art. If we look at the richest and most costly productions that have been exhibited, and carried off prizes at the international exhibitions of late years (and we have no other standard of easy comparison), it will be found that French cabinets, tables, and chairs have served as models to the successful competitors. There is a decided English type in the satinwood furniture of Messrs. Wright and Mansfield, and there is some invention, though not always happy, about our designers of mediæval furniture. These productions are, however, too apt to be heavy and ecclesiastical, to follow rather the types of stone constructions, and the teachings of the admirable plates of Viollet-le-duc, than the lighter work, inaugurated with so much power and success by Pugin. There is a company of artists, Morris and Co., who have combined painting and woodwork, and produced excellent results; but they have had few followers, or rather few successful followers. Fourdinois, master of a great Paris house, has produced Renaissance work which, for design, artistic carving, &c., has had no competitors of equal merit. His workmanship, however, can scarcely be called equal to the best of our own. Grohé, and many others, maintain the reputation of Parisian workmen in this respect.

Italy, so long the source of the greatest efforts in

wood sculpture, workmanship, and decoration of every kind, has fallen behind in the race, partly because the French are so much more rich and luxurious, in comparison to their relative state three centuries ago, and partly for a reason which shall be touched on presently. The Italians, however, have produced admirable carving in their own walnut-wood, which is matchless for colour and grain. This is the work of Giusto, of Florence, and of Barbetti, of Siena, who carve old Renaissance Italian woodwork, and produce furniture of all kinds and of all scales, from sideboards and cabinets to caskets. A beautiful specimen of marquetry, but of a small size, was sent to Paris by Gatti, and it is worthy of the best days of Italian woodwork. It consists of ebony, inlaid with mother-of-pearl, ivory, and pietra dura. Of commoner and cheaper furniture, the chairs of Chiavari are unrivalled examples. The seats and backs are of grass, gracefully plaited, the woodwork is a model of lightness, convenience, and comfort. Figure work in marquetry is made in considerable quantities at Nice, where orange, olive, and other hard woods are to be had easily.

The Austrians and the States of North Germany are good wood-workers. The manipulation of the latter is the best, but there are, perhaps, more artistic and imaginative qualities in that of the former. The Swiss and the Tyrolese are good carvers of small toywork, such as little images and compositions. It often happens that excellent results of this kind are produced on a small scale, when they are inferior on a larger. The Dutch are very fair carvers of fine work, admirable

for engineering, architectural, and other large carpentry. The Belgians are excellent both in carving and in cabinet-making. Their school of carvers in oak has never died out since the sixteenth century, and they can boast a more unbroken succession of good productions in this line than, perhaps, any other nation of modern Europe, after the Italians.

I have in these pages had to point to a broad fact which will not, I believe, be disputed, viz. that in the highest qualities of wood sculpture and cabinet-work, the French have long borne the palm of superiority. In saying this I do not, for an instant, deny that such workmanship and materials as are employed by the Hollands, Grahams, Gillows, Wrights, and other leading English houses, are of an excellence scarcely equalled, certainly not surpassed, by our neighbours over the Channel. Nevertheless, taking the highest view of these productions as works of art of the most attractive kind, it must be allowed that in our most successful efforts we follow the lead of France. In the great European tournaments of artists and traders, French exhibitors have had the greatest success. Why is this? I will give the best answer that I can.

In the first place, ever and always, *race* counts for something. The Greeks first, then the Romans, the Italians, and other races that have come nearest to these originals, have had certain gifts *as races* (as we also have our own gifts). The immemorial inheritance of the old Greek culture carried this gift of a sense of classic beauty to all the races that succeeded to the *Roman Empire* and to the Italians first. The French

also were for many centuries a portion of the Empire, sharing all of its traditions and ideas. Excellent sculpture in bronze and marble has been found all over Gaul. And what was, as it were, latent in the capacity of the race, found expression when peace returned in the eleventh and subsequent centuries to Europe. The arts revived. The remains of the architecture of mediæval France show how great that race was in that art. Enamels, ivory carvings, &c., were carried to a high pitch of excellence in that country in the middle ages. In the Renaissance period, it was France that first after Italy caught the prevailing spirit. Italian princesses became queens of France, and Francis the First was a great patron of Italian learning, greater than our own Henry the Eighth, who was by no means behindhand as a lover of art. Now it is quite true that the architecture and wood carving of mediæval England stood very high in comparison with the rest of Europe. It is also true that in the sixteenth century the Tudor princes were genuine patrons of both art and literature, and collected libraries and galleries of pictures. But the French were in advance of us even then.

This great innate love of the arts has always been carefully fostered in France, and the rulers of France took wise precautions to promote the skill of artists and workmen. Seeing the excellence of many classes of manufacture in Italy in the seventeenth century, a period during which Europe was living on the traditions and glory of the past, Colbert, the powerful minister of Louis XIV., took the most energetic means

to establish schools and factories in France in which good workmen and artists could be trained, and costly productions executed. This wise expenditure ensured France two centuries of supremacy in the sumptuary arts. The Gobelin tapestry works, the great lace establishments, the manufacture of plate looking-glasses, later that of the Sèvres porcelain, all these were set going by the help of Italian workmen, or artists carefully trained in Rome were set over these several factories. It was no easy matter to obtain lace or glass-makers from Venice, but no expenses were spared to effect the object in view. To natural aptitude therefore was added the very best and most careful training; and we, who grudge the opening of the public purse for such objects, should do well to study this wise political economy. Not only have the best workmen and artists been engaged in these factories, but they have passed through them and afforded a supply of good hands for private manufacturers. Never was money more prudently laid out, for it secured the command of the market in expensive and luxurious domestic art, which France still enjoys. It would be well if to our South Kensington schools, with their enormous and not always effective machinery, we could add some teaching of this higher kind of industrial production, and actually make a certain quantity of Government furniture, or other fine fittings and wood and stone work, say for portions of the public offices, museums, &c. Good workmen, ready and skilful designers, would pass through such workshops, to the infinite improv[illegible] trade.

The firm of which I have given so many details of management, already has had the wisdom to send to France for designers and draughtsmen, when they could not get the talent they required at home. Alfred Lormier, Eugène Prignot, and Thomas Jacob are at the head of these designers. In many instances the actual cost of designs exceeds that of the production of the pieces themselves. Seven hundred pounds per annum is not considered an excessive income for a principal designer, for whom assistants and draughtsmen are provided in addition. To this should be added the large sums paid to architects, such as the late Mr. Owen Jones, for special designs over and above what is constantly in demand for the usual requirements of the trade. From 1000*l.* to 1500*l.* per annum may be spent in this particular matter without its being looked on as an unusual outlay.

And yet we consider that English furniture makers are at a disadvantage when compared with French. No French firms embark such amounts of capital or expend such enormous sums yearly. They do not undertake such various branches of the furnishing business, curtains, carpeting, &c., at the same time and under the same roof as their wood manufactures. Hence the higher professors of this branch of industry can bestow more personal thought and care on the smaller cycle of occupations which they propose to themselves.

A third advantage that the French have is in the superior intelligence of their patrons or buyers. There are enormous fortunes in England, and the

owners and makers of them spend money liberally in furnishing their houses and in filling galleries with paintings. On the whole, however, they are more in the hands and under the direction of dealers and makers than the French. Our great capitalists have, as a body, not a very enlightened judgment on questions of art. Leaving out of view the highly-educated gentleman and practical connoisseur of either nation, I think that the Continental tradesman and artisan will have his house or his rooms more gaily and agreeably furnished than the person of corresponding class in this country. With our solid national virtues and good qualities, we rather bow to our neighbours as our superiors in matters of taste. Hence the consumer knows better what he wants, has a better (though by no means always a right) judgment as to whether the goods he buys supply that want. Again, the producer, if he makes good things and does his best, is pretty sure that his exertions will be appreciated. It is melancholy to walk through shops or warehouses in which first-rate design and work may be seen, and to find side by side with them vulgar and inferior productions. If we ask the reason of this, we are told always that a large class of buyers *must* be supplied with these ugly productions.

Now, if we walk down the arcades of the Palais Royal there are flimsy, staring, and vulgar ornaments and knick-knacks for sale no doubt; but most of these objects of flimsy make, or occasionally coarse and vulgar taste, are rather exaggerations of better designs, and the sense of beauty is rarely entirely wanting. I

do not think this much can be said of certain industrial products in England, whether of the kind seen in the Palais Royal, or of the woodwork and furniture that I am discussing. A measure of mental culture in regard to all matters that please the imagination is more evenly distributed in France than in our own country. Drawing schools are more common, and the knowledge of figure drawing and figure sculpture is more widely spread. In the comparison of the finest productions of English furniture and cabinet making with the finest of the French, nothing strikes us more than the superiority of the French in drawing, painting, and sculpturing the figure, whether on fans, porcelain, or the incomparable cabinet work of Henri Fourdinois, already noticed.

The Past and the Future.

A few words must be given to a retrospect of the state of this branch of the national industry, and to its prospects. If we look back twenty years to the furniture exhibited in London in 1851, the improvement of the present time seems incredible.

I will take that Exhibition, the first of these modern displays of all sorts of products of labour, as a point of departure for my review.

In 1851 the commissioners directed that a complete report should be drawn up on the subject of the decorative treatment of manufactures of all kinds, including the particular class of objects under discussion. The author of this report calls attention to what should be

the first consideration in the construction of objects for daily and personal use. From the continual presence of these things, "defects overlooked at first or disregarded for some showy excellence, grow into great grievances when, having become an offence, the annoyance daily increases. Here at least utility should be the first object, and as simplicity rarely offends, *that ornament which is the most simple in style will be the most likely to give lasting satisfaction.*" The italics are my own.* Yet on examining the furniture on the English side, the reporter could but notice how rarely this very obvious consideration had been attended to. "The ornament of such works on the English side consists largely of *imitative* carving." Ornaments consisting of flowers, garlands of massive size and absolute relief, were applied indiscriminately to bedsteads, sideboards, bookcases, pier-glasses, &c., without any principle of selection or accommodation. "The laws of ornament were as completely set aside as those of use and convenience. Many of these works, instead of being useful, would require *a rail to keep off the household.*" Even the admirable carving of Rogers seemed scarcely in its place. Animals were carved as chair legs, swans to support tables, and nets, admirably cut and pierced, ornamented the frames of looking-glasses.

Now it is certain that for many, if not for most glaring inconsistencies of this kind, some sort of precedent may be found, such as the naturalistic carvings of Grinling Gibbons, whose flowers and tendrils stood

* Supplementary Report, chap. xxx.

out with the grace of nature, and shook with the wind or the rumbling of the coaches that passed by the rickety lodgings in which the artist worked. So also we might find, amongst the designs of Raphael in the Loggie of the Vatican, bold departures from good tradition. But bold men and great artists are justified by the power and extraordinary beauty of what they do—and what they know they can make effective—and no one should imitate these exceptions to well-digested rule till they are artists as great as their models, and by that time they will not be imitators of eccentricities. Feeble departures from rule are always failures.

These strictures were not applicable to the entire British side of this class of work, but far from it. One or two notable exceptions may be quoted, such as a bookcase carved in oak, exhibited by Mr. Crace, bought by the commissioners and added to the Kensington collections. This and a few other works "are particularly to be commended for their sound constructive treatment, and for the very judicious manner in which ornament is made subservient to it. The metal work is also excellent, and the brass fittings of the panels of the bookcase deserve to be studied, both for the manner in which they have been put together and for their graceful lines."

Speaking generally, the best woodwork exhibited was that of the French makers. It is noticeable that the French taste was then, as it has certainly continued to be, a phase of Renaissance art, more showy and luxurious than the art of the best period in that country, whether under Jean Goujon, Philibert de

l'Orme, or the Chevalier Lebrun, who was made designer to the Government factories in Paris in the seventeenth century.

Four years later, in 1855, in the Paris Exhibition, our furniture and woodwork had made a stride forward which was still more marked in the London Exhibition of 1862. By that time our leading houses had appreciated the necessity of obtaining talented designers and foremen, and in many instances they had employed the first architects of the day to give them drawings. The result was a great progress. While the French, indeed, continued to produce very fine pieces, some on the best models, or rather after the principles of the best periods of the Renaissance, our own cabinet-makers had run far on in the same direction and in many others, for the mediæval feeling had still a strong hold on the taste of English architects and their patrons.

The greatest change, however, that has been brought to notice by a vast medium of advertisement, such as a general exhibition of manufactures, was that which the Paris Exhibition of 1867 brought to light. Fifteen full years had passed since public attention had been called to any careful comparison between the state of our furniture and the decorations of the interiors of our houses with those of other countries, and the advance was incalculably greater on the part of this country than on that of the other competing nations.

It is worth remarking, that in three great comparative Exhibitions, and particularly in that of 1867,

national tastes and peculiarities seem to have been so completely pared away that it becomes difficult to keep the productions of the North and West of Europe from those of the South or the East, distinct in one's mind. Each nation followed the fashion of the works that had obtained the best prizes at former exhibitions.

So much, then, for the past. Now comes the question of the future. Europe and its various component nations seem once more to be tending towards a community of ideas on the subject of which this paper treats. It has been so more than once already during long periods, such as the thirteenth, fourteenth, and fifteenth centuries, and again during the sixteenth and seventeenth. The excellence that was shown in woodwork, furniture, carving, &c., during those distinct periods was, no doubt, greater in such a country as Italy, where certain inherent natural advantages prevailed. Italians were, and in a measure still are, born artists. Their dress, architecture, painting, sculpture, were of a more beautiful kind than those of Northern races. I need not enter on metaphysical discussions to prove this. *But this was not all.* In the period of which I am treating, the arts were matters of serious concern. During certain ages they were the servants of religion. They not only helped out the representation of sacred things and invited the devotion of the ignorant by setting forth some shadow of the beauty of the other world and its inhabitants, as they understood them, but they civilized. By imparting a love of beautiful objects, they humanized men whose ordinary

lives were either rough and violent, or were oppressed by richer classes and very miserable. Great pains were therefore taken to foster the arts. Religious bodies took up, protected, and patronized artists and the arts which they professed. The vast cloisters had feudal power and independence, and their peaceful retirement was a place of refuge during the wars that were so general. Besides this, guilds or brotherhoods of craftsmen were encouraged and protected in the cities by their own special codes of laws. Each confraternity took in and taught its own apprentices. In time they became free of their guilds and practised for themselves.

At a later period, kings, princes, and noblemen took artists into their own houses and gave them every opportunity of self-improvement. Thus with all the natural aptitude of the Italians, careful learning, training and apprenticeship under the eye and in the constant presence of a master were considered indispensable. The natural talents of Italians enabled them to assimilate a greater amount of training and instruction, and to acquire a greater amount of accomplishments than other races. What these enlightened leaders of opinion did in Italy, Colbert, a powerful minister, under the steady approval and support of an accomplished king, did for the French nation.

Finding that the best glass makers, lace makers, painters, and sculptors were Italians, he obtained their services, bribed them, smuggled them into the country, in short, would not be baffled in his object.

We are neither Italians nor Frenchmen, and indeed,

speaking generally, we have not the sense of beauty and propriety in art that those races have.

It is enough to look at modern London, to listen to the disputes of committees of management or selection, when a new public building, a new street, or a gallery is to be erected, and to take a glance at their choice when made, to see what we are in this respect. But we do produce men of genius, not only statesmen, sailors, and soldiers, but also poets, painters, and carvers, and we have not been without sculptors. We require men with genuine knowledge and general love of art in the van, and good schools of drawing from one end of the three kingdoms to the other. The latter want has been met, we are glad to be able to say, and we must hope that the training in our art schools will be far more effective and real, than it has been hitherto. It is everything to have set them going, and those ministers and officials who have helped on such a movement deserve the gratitude of all Englishmen.

The Kensington Museum and the exhibition by Sir Richard Wallace of his beautiful furniture, are in themselves powerful helps to improvement. It must be remembered, however, that guns and ships do not of themselves make armies and navies, neither will schools with formidable tables of expected accomplishments make scholars and artists. Colbert, who took such practical, and, as they have proved, such effectual steps to teach his countrymen, set his scholars not only to pass examinations but to work and produce. In other words, as Michael Angelo, Leonardo da Vinci, Raphael, and other great men had pupils and made them work with

themselves in the production of their greatest works, so Colbert made Le Brun and others the heads of actual factories.

I am not now treating of painters and sculptors, but of wood carvers and cabinet-makers. Nevertheless in these schools scholars were actually trained to be sculptors and painters, and incidentally they worked more or less at these arts, while they were in the royal factories. André Boule, the great cabinet-maker, was established in the garret floor of the Louvre, a vast place; and made his cabinets, taught his pupils, and got together a great number of works of art, of which he was an amateur and collector. The man was there himself, inspiring his pupils, helping them on, assimilating them to himself. Private firms, however generously they deal with their head designers, cannot ensure such a position as this, and corresponding results in the way of artistic production cannot be looked for.

On the other hand, cannot something be done with the national teaching establishments, at South Kensington, in the potteries, in the weaving districts in Manchester? We have no want whatever of wealthy buyers. The great modern fortune holders are foremost in expenditure on sumptuous furniture and house decoration. Would not the trade, and would not the public benefit by a school of actual workmen and artists, not only competent to produce chalk drawings of the Apollo Belvedere and other stock themes, but to enter into the beauty [illegible] tic productions for every-*day delight and* [illegible]

I may point to the immense effect produced by single artists who have embarked on this quest with some confidence and zeal. Wyatt in his day; Nash in his; still more Pugin in his—what a number of separate branches of decorative trade production they animated! Morris and Co., a company of artists, are influential out of all proportion to the mere extent of their operations, which, unfortunately, is but limited.

That English sumptuary art has made enormous strides, I have fully admitted. But we might do, and ought to do, much more. The tyranny of the modern London housebuilder, and the poor and vulgar houses in which rich Londoners are content to live, are not yet touched. New streets rise up, containing one or two hundred houses each the counterpart of its neighbour, with every staircase, door, window, &c., precisely in the same place. This is for the greater money gain of the builder alone. Are Londoners never to inhabit houses built to suit their own tastes and wants?—(and no two hundred families will or can all have the same.) Are the same plaster ceiling patterns, the same stucco window-frames, and vulgar fireplace ornaments of the modern builder to be forced on us all without choice or variety?

We hope for something better. But we have done no more hitherto than make a beginning. If we advance, it must be under the direction of men, not under the wrangling of committees, however accomplished some of their members may be. And as regards furniture and interior art, we want not only that costly, but that inexpensive furniture should be

good of its kind. To be this, inexpensive woodwork *must be simple;* deal must not profess to be oak, maple, or walnut-wood; marquetry must not be replaced by coloured shams, nor stamped brass and cast iron be palmed off as elaborately-wrought metal work. Cheapness results from the restriction of labour on the object to the bare necessities of decent construction and neatness. Appropriateness, convenience, and simplicity must replace in cheap furniture and woodwork the beauty which is produced by good artists on the best materials, and on which they can be allowed the time necessary to accomplish their labours.

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